ANNUAL SCIENTIFIC REPORT 1973-74

TEA RESEARCH ASSOCIATION, CALCUTTA

OUR COVER

Spacing experiment planted in fan design at Borbhetta.

TEA RESEARCH ASSOCIATION

Annual Scientific Report

(1st April 1973 to 31st March 1974)

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Contents

	Page
Organisation	1
Senior Staff Matters	2
Trainees	2
Lecture Courses	2
Tocklai Conference	3
Visitors	3
REPORT OF DEPARTMENTS	
Advisory Department	4
Summary of Results of Advisory Department field Experiments	15
Agriculture Department	17
Soils & Meteorology Department	24
Botany Department	42
Entomology Department	47
Mycology Department	53
Biochemistry Department	57
Tea Tasting Department	62
Engineering Research & Development Department	65
Statistics Department	69
Library and Publication Department	74
APPENDIXES	
Appendix A— List of Advisory Department Field Experiments in the Member Estates	75
Appendix B— List of Experiments of other Departments in the Member Estates ..	77
Appendix C— Published Papers and papers in the Press	79
Appendix D— Summary of Meteorological observations during 1973	80

Director's Report

(1st April 1973 to 31st March 1974)

ORGANISATION

On the 31st March 1974, the Senior Staff consisted of :—

Directorate :

Director
N. K. Jain, M.Sc. Ag. (B.H.U.), Ph.D. (Illinois)

Dy. Director
D. N. Barua, B.Sc. (Cal.), Ph.D. (Cantab) (Retired July 1973)

Administrative & Finance Controller
J. Tessier-Yandell, M.I.I.P.M., A.M.I.P.M., A.M.B.I.M.

Accounts :

Accounts Officer
S. Mazumdar, B.Com. (Cal.), A.C.A.

Maintenance :

Station Engineer
G. B. Singh, A.M.I.S.E.

Medical :

Medical Officer
Dr. (Major) S. W. Rohman, M.B.B.S.

Library & Publication Department :

In-Charge
J. N. Sharma, M.A. (Gau.)

Soils & Meteorology Department :

Soil Scientist
S. K. Dey, B.Sc. (Cal.), Assoc. I.A.R.I.

Senior Scientific Assistants
N. G. Bhattacharjee, B.Sc. (Cal.)
A. K. Sengupta, B.Sc. (Cal.)

Botany Department :

Senior Botanist
D. N. Barua, B.Sc. (Cal.), Ph.D. (Cantab) (Retired July 1973)

Plant Physiologist
W. Hadfield, B.Sc., Hons. (Liv.)

Plant Breeder
H. P. Bezbaruah, M.Sc., Ph.D. (Gau.)

Senior Scientific Assistants
K. N. Dutta,
B. N. Gogoi, B.Sc. (Gau.)

Agriculture Department :

Agronomist
F. Rahman, M.Sc. Ag. (Bihar), Ph.D. (I.A.R.I.)

Second Agronomist
B. C. Phukan, B.Sc., Ag. (Gau.) A.I.F.C.

Manager, Borbhetta Experimental Estate :
H. N. Sharma, B.Sc. (Cal.)

Entomology Department :

Entomologist
B. Banerjee, M.Sc. (Cal.), M.S. (South Illinois), Ph.D. (Lond), F.A.Z., F.R.E.S. (London)

Senior Scientific Assistants
N. S. Sengupta, B.Sc. Ag. (Cal.)
M. C. Katoni

Mycology Department :
Mycologist
G. Satyanarayana, B.Sc. Hons. (Andhra), Ph.D. (Madras), F.B.S., F.I.P.S.

Biochemistry Department :
In-Charge
S. Chakraborty, M.Sc, Ph.D. (Cal.)

Tea Tasting Department :
Tea Taster
R. P. Basu,

Third Tea Taster
A. K. Das, B.A. (Cal.)

Second Tea Taster : *West Bengal*
S. Sen, B.Sc. (Cal.)

Engineering Research & Development Department :
Senior Research Engineer
D. N. Barbora, B.Sc. Mining (B.H.U.), M. Sc. Eng. (Lond.), D.I.C.,M.I. Ag.E.

Second Research Engineer
T. C. Baruah, B.Sc. Hons., (Gau.), B.Sc. Mech. Eng. (B.H.U.), M.Sc. Mech. Eng. (Manchester)

Statistics Department :
Statistician
A. K. Biswas, M.Sc. (Gau.)

Advisory Department :
Chief Advisory Officer
W. J. Grice, M.A., Dip. Ag. (Cantab)

Senior Advisory Officer
P. C. Sharma, M.Sc. (B.H.U.), Ph.D. (London), F.L.S.

Advisory Officer : South Bank : *Upper Assam*
T. K. Ghosh, B.Sc. (Patna), Ph.D. (Cornell) Assoc. I.A.R.I.

Advisory Officer : *Lower Assam*
B. Borthakur, M.Sc. Ag. (Gau.)

Advisory Officer : *North Bank*
H. Mitra, B.Sc. (Cal.)

Advisory Officer : *Cachar*
J. Chakraborty, M. Sc. Ag. (Gau.)

Advisory Officer : *West Bengal*
S. Basu, B.Sc. Ag. Hons. (Delhi), Assoc. I.A.R.I.

Advisory Officer : *Dooars & Terai*
B. C. Barbora, M.Sc. Ag. (I.A.R.I)

Advisory Officer : *Darjeeling*
S. K. Sarkar, B.Sc. (Cal.), B.Sc. Ag. (B.H.U.)

SENIOR STAFF MATTERS

Retirement

Dr. D. N. Barua, Deputy Director cum Senior Botanist retired on 31st July 1973 and joined Assam Agricultural University as Adviser to V.C.

Mr. W. J. Grice, Chief Advisory Officer retired from TRA Service on 31st March 1974.

TRAINEE

Four Research Students continued to work at Tocklai throughout the year under C.S.I.R., Junior Research Fellowships, two with the Botany Department and one each with Soils & Meteorology Department and Engineering Research & Development Department.

LECTURE COURSES

The following lecture courses were held during the year:—

Surveying and Drainage Course

(a) For Govt. approved and Estate surveyors from 19th to 21st November, 1973.

(b) For planters
1st Course from 26th to 30th November 1973—25 planters attended.

2nd Course from 3rd to 7th December 1973 — 23 planters attended.

3rd Course from 10th to 14th December 1973—26 planters attended, all dates inclusive.

TOCKLAI CONFERENCE

The twenty-eight Tocklai Bienniel Conference was held at Tocklai on 13th, 14th and 15th November 1973. The Conference was attended by 114 delegates representing the various tea producer Associations and tea districts of North East India. The theme of the conference was Objectives of Tea Industry in N.E. India and the role of Tocklai in achieving them.

VISITORS

Some of the visitors in addition to local planters are listed below :—

Sri Tuka Oraon, M.P.,
Sri K. V. Ahamed Bavappa, Director CPCRI,
Dr. M. S. Swaminathan, D. G. I.C.A.R,
Mr. R. S. Isherwood, Cyanamid International,
Dr. W. C. Von Meyer, Rohm & Hass Co.,
Sri P. B. Suchak, and Sri R. K. Datta, Indofil Chemicals Ltd.,
Sri R. L. Jain, Indian Petrochemicals,
Mr. T. F. S. Scott, British Council Division, British High Commission,
Sri S. P. Mathur, Dunlop India Ltd.,
Sri P. K. Daga, President and Sri P. K. Bagla, Vice-President of TAI,
Dr. R. R. Agarwal and Dr. P. C. Goswami, Assam Agriculture Commission,
Mr. R. H. S. Fennell, World Bank,
Sri M. Aravindan, I.C.A.R.,
Sri S. R. Mhatre and Sri S. Banerjee, Ciba of India,
Sri A. N. Kalra, IISR.,
Mr. J. B. Low, African Highlands Produce Co. Ltd.,
Dr. D. E. Barnes, Ansul (Malaysia) SDH.,
Mr. F. R. Wilson, Duncan Macneill & Co.,
Sri Md. Ali, Chairman Bangladesh Tea Board and
Dr. K. A. Hasan, Director, Bangladesh Tea Research Institute, Srimangal, Sylhet,
Mr. M. V. Mariott, Reading University,
Mr. M. Lamond, L.S.C., I.T.A.,
Mr. Aegidius Klaverblad, University of Amsterdam,
Sri Biswanarayan Shastri, M.P.,
Dr. Ashok H. Manchande, Tropical Products Institute,
Sri N. D. Jayal, Development Commissioner, Manipur Govt.,
Sri Sadhan R. Sarkar, I.I. Agri.,
Dr. Yuzo Futsuhara,
Dr. Masaharu Shimizu and Mr. Hideki Ogawa, Nagoya University,
Sri M. C. Muthanna, Bombay Burma Co,
Sri K. Rabindran, Hindustan Lever Ltd.,
Sri P. P. Lakshmanan, Ministry of Agriculture,
Sri D. Basu, Ministry of Finance,
Sri H. P. Choudhury, M.P.,
Said N. Miraskari, Iranian Tea Co.,
Mr. M. Ali, Cheitassi, North Tea Department, Iran,
Mr. T. R. Crook, I.T.A. (London),
General J. N. Choudhuri, Andrew Yule & Co. Ltd.,
Sri S. Doley, C. F. Bhutan,
Sri R. K. Hranga, DST, Arunachal Pradesh,
Mr. N. S. Coldwell, James Finlay & Co. Ltd., Glasgow
Prof. G. Pilleri, University of Berne,
Dr. H. N. Graham, T. S. Lipton, Inc. U.S.A.,
Mr. Hugh Ferguson, James Finalay & Co. Ltd., Glasgow,
Sri M. Ganapathi, Mysore Insecticides Co. (P) Ltd.,
Mr. Lars Fredikssón, Ag. College of Sweden,
Mr. L. G. Pickering, U. S., Consul General and
Mr. R. McCormack, and Mr. A. P. Burlegh,
Sri J. M. Sehgal and Sri S. K. Sachaeva, I.D.P.L.

Advisory Department

1. General

The Advisory Officers continued to share their responsibilities in their respective areas according to the reorganisation of this Department initiated towards the end of 1972 as mentioned in the last Annual Report. Since Mr. S. K. Sarkar was relieved of his responsibility for Terai, he has been able to pay more attention to the Darjeeling problems. Mr. J. Chakravartee, Advisory Officer, Cachar, may increase his sphere of activities by including estates in Tripura in addition to Cachar.

The miniature factories at Nagrakata and Ging Tea Estate have been operating as per schedule and the services of the Second Tea Taster stationed in West Bengal have been found useful.

Mr. W. J. Grice, Chief Advisory Officer, left Tocklai on retirement on 31st March 1974.

2. Visits

During the period under review, the demand for advisory visits was heavy and the advisory officers made every effort to visit each member estate twice in a year. As a policy, special visits were discouraged for maintaining the normal progress of work and devoting more time on experiments; consequently the number of special visits were considerably curtailed.

The table below shows the number of visits paid to the member estates in each district.

District	No. of visits		No. of member estates visited		No. of member estates	
	1973	1972	1973	1972	1973	1972
South Bank	282	270	202	170	265	243
North Bank	119	199	59	77	88	83
Cachar	119	88	42	31	53	35
Dooars	157	161	76	68	89	82
Terai	20	43	14	20	20	20
Darjeeling including Sikkim	101	96	46	46	49	50
Total	798	857	439	412	564	513

The decrease in the number of visits on the North Bank, Dooars and Terai is due to the fact that the Advisory Officer, North Bank was out of touring for about six months, the Advisory Officer, West Bengal, for four months, and the Advisory Officer, Dooars & Terai, for three months. During the period, the advisory officers could devote more time on experiments and 134 visits were paid to the experiments by the advisory officers during the period as against 43 visits in the previous year.

Along with the ASC meetings, mini-seminars on different aspects of tea husbandry were conducted. These seminars were a great success in a sense that they were well attended and well appreciated.

3. Crop and weather

(a) Assam

The western half of North Bank, Golaghat, Nowgong and Cachar had experienced a prolonged drought early in the season and thereby lost a considerable amount of early crop. The rest of the area, however, did extremely well due to even distribution of rain. The major portion of the Brahmaputra Valley and Cachar had also seen a dry spell in July/August which depressed the flush to varying extent. A few good showers in the back end helped many estates produce substantial quantity of crop and quite a number of estates who were running behind in crop could make up the loss. It is, however interesting to point out that inspite of unfavourable climatic conditions early in the season, the total production of Assam was well above the previous years production.

(b) West Bengal

Normally West Bengal is prone to drought and, as usual, all districts were affected by early drought but enjoyed favourable climatic condition during the main and backend flush period. The season ended up with substantial amount of extra crop.

4. Land planning and drainage

Since the initiation of the drainage course in 1969, a good number of planters have been given a fair idea on land planning and drainage and the

industry has been greatly benefitted from this Course in a sense that more and more people are becoming aware of the importance of land planning and drainage. In course of touring, a great deal of time had been spent by the advisory officers on land planning and drainage, as a result, considerable improvement on drainage took place specially in areas suffering from imperfect drainage system. Non-availability of adequate funds and trained surveyors were two major factors holding back the progress on drainage and planting according to the topography. The progress made on land planning and drainage district-wise is discussed below.

(a) **South Bank**

The situation with regard to drainage is unique on the South Bank for the reason that suitable outfalls are not available in many areas due to high water table. However, the advisory officers while on tour, tried to explain the importance of an outfall in a drainage system, and where it was necessary, stress had been given on the need of a level survey of the drains in relation to the flood level of the river. On the whole, the progress made on drainage during the year was not significant and besides other factors, the limitation of funds and situation of the estates, were the main reasons for the non-implementation of the drainage scheme. Where drainage systems have been put in correctly according to the advice, better results were obtained.

(b) **North Bank**

In general, the drainage problem is not as great on the North Bank as it is on the South Bank. The river Brahmaputra is not a problem for North Bank though there are some problem areas. The majority estates besides implementing the present idea of drainage in the extensions and uprooted areas, had initiated level survey of the existing young tea areas and put in drains according to the plan. Some estates have their own surveyors and were able to plant out tea according to the topography in time. On several occasions, the advisory officer had to guide the surveyors in level survey and help prepare the plan, but many estates could do planning without the help of the advisory officer which was really appreciated. On the whole, progress made on the North Bank is quite satisfactory.

(c) **Cachar**

In Cachar, paucity of trained surveyors has been a limiting factor in holding back planning a drainage system according to topography and the advisory officer could do very little in implementing the new idea on drainage but efforts were made to convince the people to lay out a drainage system according to the lie of the land. The teelas and flats are the main features of Cachar tea land and the drainage problem in tea is mostly due to the seepage water from the teelas to the flats and non-availability of suitable outfalls. The advisory officer, in course of touring, made it quite clear to the estates concerned that the existing shallow perimeter drains are unable to deal with the seepage water and a deep perimeter drain is a must to solve the problem. Emphasis was also given on suitable outfall as and where it was necessary, because a great deal of tea in Cachar actually suffers from inadequate outfall. In teelas, the main object is to dispose of surplus water efficiently. The existing blind contour drains do not dispose of water properly, rather they are overflowed and encourage soil erosion. However, estates were told to provide shallow collector drains taking them down the natural depressions just to prevent overflowing of contour drains and dispose of the surplus water safely.

(d) **Dooars and Terai**

Although more and more estates have realised the importance of land planning and topographical planting, there is still a certain amount of reluctance to go ahead with the new system. On many estates even the extensions were planted out disregarding the topography of the land. It may, however, be mentioned that the planters are more keen to provide drains prior to planting. The Advisory Department had offered all possible co-operation to the estates willing to do level survey and put in drains as per plan and this good work actually benefitted a large area of young tea. On many estates the main drains were not big enough to carry away surplus

Devastating scouring of an unusually small main drain. This happens when a drainage system is not based on land planning.

water quickly and were posing drainage problem. Emphasis was given on the size of the main drain on the basis of catchment area, rainfall and soil type. Where this was done, better results were obtained. On several estates, old narrow culverts on the main or outlet drains have been creating drainage problems. Widening of these culverts should improve the drainage problem. In course of touring or in group meetings, emphasis was given on a well laid out drainage system as this not only solves drainage problem but also conserves moisture for the dry weather.

(e) **Darjeeling**

In Darjeeling soil erosion rather than drainage is a problem. So far, very little work has been done on catchment planning and safe disposal of storm water without causing soil wash. However, the advisory officer time and again has emphasised the ill effect of soil erosion from tea areas and suggested remedial measures. Since there was very little extension or replanting, the advisory officer was asked very seldom to advise on safe disposal of water and soil conservation. This unfortunate situation is primarily due to inadequate fund and lack of interest in replanting.

5. **Tea Husbandry**

I. **Pruning Cycle**

(a) **South Bank :** The three-year pruning cycle of prune-deep skiff-medium skiff was followed by most of the estates who actually prefer to maintain a happy medium between crop and quality. The estates keen on crop followed either LP - UP-UP or LP - UP - DS - UP - or LP - DS - MS - UP. A few quality estates had, however, preferred LP - DS cycle. The advisory officers had explained on many occasions the necessity of black plucking for tea on a longer pruning cycle in the unpruned or light skiffed year. Stepping up over normal unprune had been a great success and it is very likely that many more estates will follow it in future.

(b) **North Bank :** The majority estates on the North Bank had switched over to four-year cycle. Only a few estates followed LP - DS - MS cycle. It is, however, interesting to note that a few quality estates had introduced unprune without losing quality and this was possible due to efficient plucking. Several estates who went for 5-6 year pruning cycle had also switched over to four-year cycle as there was no extra gain in terms of crop and quality, from a longer pruning cycle.

(c) **Cachar :** The majority of estates have been leaving a fairly large area under light/level-off skiff and unprune as the economy of Cachar estates mainly depends on crop. It is not uncommon to find tea unpruned for 2-3 years. Efforts were being made to introduce a suitable four-year cycle of LP - UP - DS - UP and thereby bring the estates under a definite cycle. It has, however, been observed that inspite of drought, the Cachar estates make a good amount of crop from unpruned tea.

(d) **Dooars & Terai :** The major portion of Dooars and the entire Terai are prone to drought and there are estates where shade is not uniform. Several estates have patches of unsuitable soil.

The advisory officer had to consider all these factors while recommending a longer pruning cycle and the estates were told that they must not have unpruned/levelling-off or light skiff in areas which are prone to drought. In general, a four-year cycle is followed as the crop is the main factor determining the profit of an estate.

(c) **Darjeeling :** The economy of a Darjeeling estate depends primarily on the first and second flush crop and advices are given to ensure maximum first and second flush crop. Where labour is assured, the estates had gone for a longer pruning cycle by introducing deep skiffing.

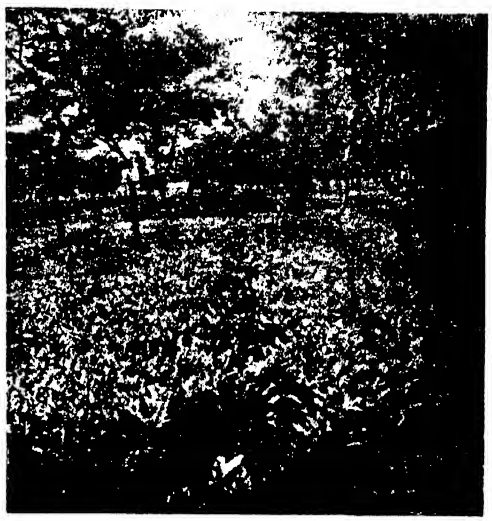
II. Time of pruning/skiffing

The time of pruning and skiffing is a most important factor determining the yield of tea in the early flush period and the advisory officers are well aware of this factor and advised the estates to prune/skiff their teas at the right time. It was, however, observed that pruning or skiffing in drought resulted in dieback and decrease in yield. In the drought prone areas the estates were told to prune their teas before the signs of droughts are exhibited.

III. Plucking

The industry loses a considerable amount of crop by not plucking tea efficiently and correctly. Several estates could not pluck their teas efficiently due to shortage of labour and thereby could not gain much from a longer pruning cycle. The rise of table in a longer pruning cycle is a serious matter and its impact on crop was explained clearly to the estates concerned. The relation of skiffing height and tipping was also dealt with during discussion and on the spot advice proved extremely useful. As regards standard of plucking, it is heartening to note that throughout N.E. India, there is keenness to improve the standard of plucking and in comparison to previous years the overall standard of plucking has improved appreciably.

Step-up plucking in mature tea has been gaining ground gradually and the results so far obtained are quite encouraging.



Clone TV 18 : First unpruned year after the frame formative prune in January 1973 at Nagrakata.

It is interesting to note that in Darjeeling, the rate of shoot growth varies with the health of tea, aspect, elevation and soil type. The advisory officer, therefore, had to emphasise these important points and suggested shorter plucking round where the growth was rapid. This system of plucking proved profitable and the table did not rise unduly.

IV. Rejuvenation

Rejuvenation pruning has been tried by a number of estates in different districts with fairly good results. It was emphasised that the teas which are poor yielding due to ugly frames and are due to stay for more than 10/12 years, should be rejuvenated. Although it was pointed out that proper infilling with vigorous clone or jat is equally important to ensure high yield, on many occasions, infilling was not done properly or the infills were not looked after well; as a result, the main object of rejuvenation was partially defeated.

V. Young tea

The modified step-up system of plucking where a frame-forming prune at a low level is done 12-18 months after decentering, has been followed by the

A well shaded teelah.

majority estates. The present method induces better spread and covers the ground while very low. As against this method, pegging was preferred by a section of people even though it is expensive and requires a lot of care and maintenance. However, all these methods will continue to be tried and the results will be known in a few years time.

Bush population is another topic quite frequently discussed and it was emphasised that a bush population between 12,000 and 18,000 per hectare could be maintained for better results.

As regards spacing, the 120 cm lane between the rows is coming into disfavour. At the moment, young plants in the extension or uprooted areas are commonly spaced at 105 cm × 75 cm × 75 cm or 110 cm × 75 cm × 60 cm and in some cases at 105 cm × 60 cm × 60 cm.

On many occasions, it was observed that young plants were plucked low for a longer period than necessary affecting thereby the health of the tea appreciably. It was emphasised that plucking low for a longer period is detrimental and the young plants should be stepped up as soon as the table will be full.

VI. **Planting**

(a) **Infilling**

While it is more or less a regular practice to infill a certain portion of tea in Assam and Dooars, very little infilling has been done in Darjeeling, Terai and Cachar. The planting materials commonly used were TV 9, Stock 203 and Dangri Manipuri. In several cases, the infills were not looked after well and as a result, a high percentage of infills either died or took a long time to come into bearing.

However, the estates were told that the infills should be given best care and maintenance so that they can come into full production quickly. The old practice of frequent low pruning of infills was discourgaged as the system does not allow the infills to develop satisfactorily in mature tea.

Tea on flat with an isolation drain at the base of teelah.

(b) **Extension**

In Assam, the majority of estates went for extension in order to use up all surplus land quickly but where land was not available, uprooting and replanting in varying percentages had been done. In the Dooars and Terai, most of the estates have used up all suitable surplus land and there is now a dangerous tendency to plant out tea in marginal land. The advisory officers while on tour, discouraged planting in unsuitable soil. In Darjeeling, planting was confined to a few estates where land was available. In Cachar, extension was seen mainly in the teelas due to non-availability of suitable land in the flats.

(c) **Replanting**

Replanting was confined to the estates which are economically better off and where surplus land for extension was not available. Tea Board subsidy, however, could encourage several uneconomic estates to go for uprooting and replanting. The advisory officers gave much emphasis on uprooting and replanting. In Darjeeling, replanting is virtually nil and very little in Terai.

VII. **Propagation**

(a) **Vegetative propagation**

The majority estates now use clonal material and the estates who were using cheaper seeds, were encouraged to use clonal material by supplying cuttings in large numbers. Very few estates now use seeds these days.

As the clone TV9 has been observed to be prone to drought and that its yield after the 4th or 5th year is not as high as the yields obtained from some of our other clones, the estates were advise to phase out the use of this clone in the extension and replanted areas and confine its use solely for infilling until such time that sufficient material from clones such as TV18 is available to take its place in the infilling programme. Most suitable clones advocated for employment are TV1, TV11, TV12, TV14, TV16, TV17, TV18, and TV19. TV20 was released in May/June.

For Darjeeling, Tea Research Association has given interim certificates to seven clones, but very few estates showed interest in vegetative propagation. Efforts were, however, made to assist the estates who were behind in vegetative propagation work.

(b) **Seeds**

Only Stock 203 had been advocated, but several estates not being able to buy Stock 203, went for light leafed inferior and cheaper seeds. They were clearly told of the consequence of using inferior seeds. Several estates however have established Tocklai Stock 449 and 450 seed baris and it is expected that a substantial amount of crop will be harvested from these seed baris in the near future.

VIII. **Fertilisers**

(a) **Nitrogenous manures**

One of the main topics that was discussed quite frequently was the level of nitrogen in relation to yield of tea. Although majority estates were happy with our recommended doses, many were inclined to apply more nitrogen to the high yielding teas. Since none of the experiments so far has indicated significant increase in crop due to extra dose of nitrogen, the advisory officers could not support the views of the people keen on applying extra dose of nitrogen. A few high yielding estates in Assam, however, were reported to have claimed better results with split doses, but none of our experiments did indicate so. In West Bengal, split application continued to be popular though not recommended by Tocklai. However, a few experiments have been laid out and it is expected that these experiments will answer to the question in a few years time.

(b) **Potash**

Application of potash is now a common practice. The rate of application varied with the potash content of the soil. It may be mentioned that the soil reports have been used as a basis in deciding the rate of potash application. The West Bengal soils have been presenting some puzzles for Tocklai, because none of the trials has so far indicated any benefit in terms of crop from high doses of potash. Even then, some estates continued to apply potash at high levels and claimed encouraging results.

(c) **Foliar application of urea**

Urea is continued to be used extensively as foliar application in almost all estates. However, the estates were told not to spray urea in the rains. Waterlogged or poorly drained teas seem to respond well to foliar application of urea.

(d) **Zinc**

Foliar application is becoming more and more popular. Estates were told to use zinc only on skiffed or unpruned teas because zinc seems to produce better results in such areas. The estates were also told that initially zinc should be used in a limited area against proper control and if found good, then only it should be used extensively. Many estates preferred to use zinc mixed with other chemicals just to save labour and time. This was discouraged in view of the fact that the beneficial effect of zinc can not be evaluated if it is used in mixture. Complaints were received from a few quarters that zinc tends to affect the tips. They were assured that this matter will be investigated.

(e) **Shortfall in manures**

The shortage of nitrogenous manure has created a problem for the industry and it is understood that many estates could not obtain their full requirement during the period under review. It is very likely that the situation will become bad to worse in the years to come. We strongly feel that unless adequate manures are available to the industry, it will be difficult to increase or even to maintain the present crop outturn in North East India.

IX. Cultivation and weed control

Manual cultivation is now confined to estates not in a position to provide funds for weedicides. Even several progressive estates could not be 100% on weedicides due to non-availability of Gramoxone. In view of the situation, many estates tried various cocktails using very little quantity of Gramoxone. It was observed that when a small quantity of Gramoxone is mixed with any translocated herbicide, the efficacy of the translocated herbicide increases appreciably. The estates already 100% on herbicides did not have much weeds problem and could manage with the limited supply of Gramoxone. A large portion of tea area had to be given manual cultivation to level up the ground for treating with herbicides. Mikania which was a menace to tea has been disappearing gradually from tea due to extensive use of 2,4-D. Unfortunately, in its place, *Polygonum* species has been presenting greater problem because it is not controlled by the herbicides commonly used in tea. In Darjeeling, the use of herbicides was confined to a limited area. Manual cultivation is commonly practised. The estates were advised to cover up the exposed root system while giving manual cultivation.

X. Mulching

The importance of mulching is well understood by the industry and almost every estate tried to mulch young teas as far as practicable. The majority estates had no sufficient surplus land to grow Guatemala and, therefore, used paddy straw, paddy husk and thatch as mulch. In a number of estates, uprooted areas were used for the supply of mulch material. This was a dangerous practice, because this will, in fact, deplete the fertility of the uprooted area. The estates were told not to follow this practice.

Citronella being a cash crop, many estates have grown this crop for oil as well as for getting mulching material. It was, however, stressed that Citronella can not be considered as a real substitute for Guatemala because of its shallow rooting system.

On the North Bank, *Mimosa invisa* is grown along with Guatemala because it covers the ground quickly and provides enormous quantity of organic matter.

In Darjeeling, the value of mulching is being understood gradually and Guatemala and Napier are being planted out in more and more areas. The heavy pruned and pruned sections are of course mulched with pruning litters. The sections which are not compact and have vacancies were given priority for mulching to reduce soil erosion.

It was also made known to the estates that from moisture conservation point of view, it is better to mulch early in autumn when the soil is still moist.

XI. Shade

(a) Temporary

Green crops which were so extensively employed in young tea have virtually disappeared from most of the estates and in view of very little benefit that can be derived from them, people were discouraged to use them. In places of green crops, closer planting of *Indigofera teysmanii* in young tea was advocated. This advice was followed by many estates. In drought-prone areas, a light stand of *Indigofera* was advocated. Judicious lopping of *Indigofera* from time to time is a common practice on most of the estates.

(b) Permanent

In Assam, *Albizzia odoratissima* is still predominant though species like *Derris robusta*, *Albizzia lebbek* and *Albizzia procera* could be seen in some estates. On the North Bank, *Acacia lenticularis* is becoming popular. In Dooars and Terai, *Albizzia chinensis* is gradually being re-introduced.

On the North Bank, as a result of thinning out of shade and removal of diseased trees, *Albizzia chinensis* has virtually disappeared from most of the estates. Introduction of this species is being considered by many estates. Even though a few estates in Upper Assam and on the North Bank have removed shade completely, Tocklai will not be in a position to comment on it until such time as controlled experiments are concluded and the long term effects are carefully studied. At the moment, Tocklai will continue to stress on shade in tea, the density of which would vary from droughty to non-droughty areas. Reshading of old teas was rarely observed though some progressive estates made it a point to establish new shade in old tea.

On many estates, young shade was not looked after well and they normally take a long time to provide useful shade to tea. It was, therefore, emphasised that the young shade should be looked after well as per our recommendations so that it can provide shade quickly to young tea. Judicious lopping of branches in heavily shaded areas was seen on most of the estates. In many estates alternate rows of trees were also taken out in an attempt to thin out shade where it was considered very heavy.

XII. Pests and Diseases

(a) Pests

Red spider continued to pose a problem in the Dooars and Terai, South Bank and Cachar. On the North Bank, red spider was seen in a few estates which could not initiate spraying at the right time.

Scarlet mite and purple mite in varying intensity were found in skiffed and young teas in all districts. TV 1 was found most susceptible to scarlet mite.

Microcerotermes is a major pest in Cachar, North Bank and in certain parts of South Bank.

Cockchafer is a common pest in the Dooars and Terai and is becoming widespread on the North Bank. The Estates were warned well in advance of its emergence through pest and disease bulletins.

Other serious pests in Assam and in the Dooars and Terai were green fly, thrips, Looper and Flush worm.

Incidence of stem borer on the North Bank has reduced considerably. A few estates in the Dooars, as usual, had suffered from Helopeltis.

In Darjeeling, green fly and scales continued to cause damage to the tea and the immediate loss of crop is more from green fly. Helopeltis and thrips were also common. The caterpillars of *Euproctis latifascia* caused severe damage in one estate in Darjeeling.

(b) Diseases

Black rot was quite common in all the districts though the intensity of attack was varying from district to district. In a number of estates, this disease has been flourishing due to longer pruning cycle and untimely and inefficient spraying. Although the seriousness of the disease was emphasised in the Pest & Disease bulletins, quite a number of estates were reluctant to spend money in controlling black rot. It may however, be mentioned that the incidence of Black rot has been reduced considerably where shade has been thinned out.

Red rust was also seen on many estates specially in young teas and the estates were advised to improve the growing condition of tea specially drainage and potash status of the soil. Copper fungicide was recommended to arrest further infection.

XIII. Agricultural machinery

Complaints against country-made power sprayers were quite frequent and the estates were advised to follow the instructions of the manufacturers most rigidly and avoid excess running hours until such time as further improvement of the products takes place. Quite a number of estates, being disgusted with the power sprayers, used Aspee Bak Pak. This sprayer is used widley for herbicide application and has been found quite efficient against black rot.

XIV. Advisory Plots and Experiments Outstation Plots

(a) General

The plots at the out stations i.e. at Nagrakata, North Bank, Cachar, are maintained mainly to distribute cuttings of Tocklai released clones to member estates. In addition, as and when possible, simple trials or observation on different field management practices are undertaken. A brief report on the work done at the outstations is given below.

(b) Release of Tocklai clones

Since 1st January 1973, the Advisory Department has taken the responsibility of supplying release clones to member estates. The details are given in the table below :

Outstation	V.P. Cuttings	Scions	Generative clones	Generative Scions	Plants
South Bank	4,51,720	3,855	2,200	780	—
North Bank	1,50,700	900	—	—	—
Cachar	1,80,190	20	—	—	220
Dooars & Terai	4,88,225	2,483	5,900	700	—

Green leaf

Green leaf harvested from the outstations plots are stated below :

North Bank	..	2,524 kg
Cachar	..	3,958 kg
Nagrakata	..	16,000 kg

(c) **Experiments**

The look-see plucking trial which was laid out in the previous year in Cachar, indicated that the treatment in which tea was plucked at 20 cm following top prune gave the highest yield. The second best was the treatment in which the bushes were plucked at 15 cm upto early August and then raised to 20 cm. The treatment in which tea was plucked at 10 cm and raised by another 10 cm in August, gave the lowest yield. This trial will be continued to complete the prunning cycle.

Agricultural Trial 1967/68

Of the 15 Tocklai clones included in the trials, at Nagrakata, 5 clones were rejected. The performance of the remaining 7 clones were closely observed.

Observation plots

The clones which showed some promise in yield in the Dooars were manufactured in the 1973 season to evaluate their cup characters. The results of tasting are awaited.

Nitrogen Response on different clones (Planted out in 1970/71 at Nagrakata)

Clones employed are TV1, TV9, TV11, TV12, TV16, TV18. Application of treatments will start in 1974.

Quality testing scheme (Dooars)

Routine work continued satisfactorily. During the year, no new estates clone was received for testing.

New Agricultural Trial (Dooars)

The trial was planted out during the year under review with six Tocklai release clones viz. TV1, TV9, TV17, TV18, TV19 and TV20, Stock 203 and eight clones earmarked for future release.

(e) **Clonal Proving Station, Darjeeling (Ging T.E.)**

Trial A : Four more clones, viz. B.777, T.253, T. 246 and Ambari AV.2/ Balai were given interim certificates. With these four, the total number of clones that received interim certificates is now seven.

Plot yield was recorded and samples manufactured throughout the season. In March 1974, the remaining two blocks were uprooted leaving five plots with clones that have received interim certificates.

Trial B, C, D & E : Yield records were maintained and observations on growth made. Samples were manufactured throughout the season. The growth of one clone in Trial C and two in Trial D was found very poor and were uprooted during March 1974.

Trial F : This trial was planted with 8 clones during the year under report. There are now 30 clones and 2 clonal seed stock under trial at the Clonal Proving Station. Their yields and cup characters are being compared against Nanda Devi Biclonal seed and China Hybrid leaf from Ging Tea Estate.

Factory : The factories were fully operational from the start of the 1973 season at Nagrakata and Ging T.E.

Nanda Devi Seed Bari (Stock 378) - Nagrakata

A small amount of seed was harvested for the first time in 1973. It is hoped that better management will result in increase in seed yield in 1974 which will benefit Darjeeling estates to a great extent.

XIV. **Meteorological Station**

In collaboration with Soils Department, regular readings were recorded in the four fully equipped meteorological stations at Silcoorie, Nagrakata, Nagri Farm (Darjeeling) and Thakurbari.

XV. **Experiments**

During the year under review, two new experiments were laid out in all districts. A complete list of Advisory Department experiments is given in Appendix A. The table below gives the number of experiments being conducted in the districts.

	In 1973-74
South Bank ..	11
North Bank ..	4
Cachar ..	6
Dooars ..	10
Terai ..	1
Darjeeling ..	4

It was proposed to lay out new experiments on rejuvenation and infilling on the South Bank, North Bank and Cachar in the next year. With the addition of a few Field Assistants, the system of collecting data has improved appreciably.

XVI. **Area Scientific Committees**

There are 9 Area Scientific Committees in the tea districts of N. E. India. Details of the number of meetings held are given below:

South Bank East ..	2
Central ..	2
West ..	3
North Bank East ..	2
West ..	2
Dooars ..	3
Terai ..	3
Darjeeling ..	3
Cachar ..	3

Along with the Area Scientific Committee meetings, the Committees also arranged seminars on different subjects and these were well attended. The details of the seminars held in the year under review are as follows :

South Bank East ..	1	Seminar on young tea.
Central ..	1	Seminar on young tea.
West ..	1	Seminar on young tea.
North Bank East ..	1	Seminar on manufacture.
	1	Seminar on young tea pruning.
West ..	1	Seminar on manufacture
	1	Seminar on young tea pruning.
Cachar	1	Seminar on young tea pruning.
Dooars	1	Seminar on young tea pruning.
Terai	1	Seminar on young tea pruning.

XVII. **Lecture Courses**

One course for surveyors on drainage and three courses on surveying and drainage for planters were also held during the year. The courses were well attended and appreciated.

Summary of Results

ADVISORY DEPARTMENT FIELD EXPERIMENTS

Brief summaries of a few interesting experiments conducted by the Department are given below.

Infilling Experiments (Nos. D. 37, D. 40, D.41, TR. 3 and TR. 4)

Results of the combined analysis of five infilling experiments conducted in the Dooars and Terai showed that in 1973 the increase in yield due to infilling in mature tea (done in 1969) was, in general, highly significant over no infilling. Infilling with clone TV9 in a hedge at 3 plants per vacancy increased the yield by 21.4% followed by 13.3% and 12.9% increases from single infilling per vacancy with seedlings and clones respectively over control.

Table showing average yield of made tea in kg/ha

Treatment	Made tea in kg/ha
T^1 = Control	1463
T^2 = Infilling with seedlings at 1 plant per vacancy	1658
T^3 = Infilling with clone 106/1 at 1 plant per vacancy	1652
T^4 = Infilling with seedlings in a hedge, i.e., double the number of plants per vacancy plus one	1551
T^5 = Infilling with clone 106/1 in a hedge, i.e., double the number of plants per vacancy plus one.	1776
L.S.D.P. = .05	127
P = .01	173
P = .001	234
CV%	8.4

Cultivation experiment (D.42)

No significant difference between various methods of cultivation and herbicide application was observed. However, this trial has again confirmed that the treatment of leaving the organic matter, i.e., pruning litters and sickled material at site definitely yielded better results than when these were removed.

Manuring Experiments
Nitrogen (D.33)

In one experiment conducted in the Dooars in sandy loam soil, results of 1973 show that application of 220 kg N/ha in 8 applications significantly out-yielded the treatments in which 110 kg N/ha was applied either singly or in 4 applications and 220 kg N/ha in two applications. However, it will be of interest to observe whether consistent results are obtained in future.

Nitrogen (A. N. 91)

The object of the experiment was to study whether mature tea having a deep root system responds to high levels of nitrogen. The levels of nitrogen applied were 100 kg N/ha, 150 kg N/ha, 200 kg N/ha and 250 kg N/ha. The experiment was initiated in 1969 and in 1971 all the plots received potash at the rate of 200 kg K_2O/ha. The statistical analysis suggests that there was no significant difference in yield between the treatments. However, a well

Table showing yield of made tea in kg/ha from 1968-1973

Treatment /Year	1968	1969	1970	1971	1972	1973	Mean
T = No fertilizer (control)	2129	1709	1774	1606	1932	1854	1834
T = 110 kg N/ha in one application	2216	1985	2066	1666	2306	2316	2092
T = 220 kg N/ha in one application	2350	1932	2084	1803	2475	2443	2181
T = 110 kg N/ha in two equal applications	2119	1886	2058	1818	2375	2501	2126
T = 220 kg N/ha in two equal applications	2342	1948	2121	1747	2421	2232	2135
T = 110 kg N/ha in four equal applications	2266	2033	2238	1823	2374	2254	2165
T = 220 kg N/ha in four equal applications	2377	2114	2249	1838	2480	2406	2244
T = 220 kg N/ha in eight equal applications	2359	2164	2124	1833	2695	2711	2314
LSD P = .05	NS	191	269	161	280	394	—
P = .01	—	261	—	—	381	—	—
P = .001	—	—	—	—	—	—	—
CV %	6.9	6.6	9.5	4.4	6.1	11.2	

1971—1973 figures are the average yield of made tea under k_20 at O kg/ha and 200 kg/ha.

designed experiment having various levels of nirtrogen, potash and phosphate has been laid out in all districts to study the response of tea to different levels of N.P.K.

Clonal response to nitrogen (D. 24 and C. 20)

TV 18 (107/4) significantly gave higher yield than all other clones as in the previous years. TV 1 followed TV 18 in its performance and was superior to TV 2 and TV 3.

A linear increase in yield due to higher nitrogen application in general was recorded upto 110 kg N/ha.

The differential behaviour of the clones to various rates of nitrogen in D. 24 was apparent as TV 1, TV 3 and TV 18 responded significantly upto 110 kg N/ha while the same dose of nitrogen failed to produce significant increase over 55 kg N/ha in case of TV 2 and 3/22. The interaction between clones and nitrogen rates was not significant in C.20.

Pruning cycle and severity of skiff (Dj 24)

During 1973 three treatments in the various pruning cycles were light pruned and three were light skiffed while two treatments each remained deep, medium and level skiffed. Level-off skiff produced significantly higher yield over deep skiff and light prune when the overall average yield was compared. However, there was no significant difference in yield between level, light and medium skiff during 1973.

Three treatments (LP-LVS-LS, LP-LVS-MS and LP-LVS-DS) completed three pruning cycle in 1973. Comparative mean yields over the three pruning cycles showed that light and medium skiff following light prune and level skiff yielded 16% and 11% more crop respectively over deep skiff following the same order of the cycle during the first two years.

Plucking experiments (Nos. A. N. 101 and A.N. 102)

These experiments were initiated in the North Bank during 1971 at two different sites with step-up and no step-up plucking in the LP-UP-UP cycle. Unfortunately, these were discontinued after the second year of the pruning cycle. It will, therefore not be possible to find out the average effect over the cycle.

During the first year (1972), all the plots of various treatments were light pruned. Plucking at 20 cm over the pruning level yielded 12% more crop than when the bushes were plucked initially 10 cm above and stepped up by another 10 cm during early August and this difference was significant.

During 1973 when all the plots were left unpruned, plucking to the janam following 10 cm step-up in the previous year gave the highest yield and was significantly superior to the 10 cm and 5 cm step-up treatment in the unpruned year. It, however, remained at par with the treatment in which plucking to janam following 20 cm tipping i.e. without any step-up in the previous year.

Agriculture Department

General

Mr. A. K. Dutta, Senior Scientific Assistant was deputed on 1.9.73 to Assam Agricultural University for a period of two years to work as Assistant Professor in the Department of Tea Husbandry and Technology. He was awarded the Ph.D. degree of Gauhati University for his thesis entitled "Effect of Certain Mineral Nutrients on Growth, Yield, Nodulation and Nitrogen Fixation Capacity of Certain Pulses".

Mr. B.C. Sarmah, B.Sc., (Agri.) was appointed as Junior Scientific Assistant on 25.3.74. Mr. Pradip Hazarika, B.Sc., was appointed as Fieldman on 20.8.73. Mr. S. N. Goswami proceeded on leave on 17.1.74 preparatory to his retirement on 11.2.74 after 34 years of service.

RESEARCH AND EXPERIMENT

Planting and Spacing

The three experiments on spacing (B 8/1, B 8/2 and B 104) continued in 1973. B 8/1 is a factorial experiment with four spacings, two clones (T.V. 1 and T.V. 9) and three levels of nitrogen. In this experiment no interaction of spacing with clone and nitrogen has been recorded. The main effects of spacing are given in Table 1.

Table 1. Yield of made tea in kg/ha.

Treatments	1969 LP	1970 DS	1971 MS	1972 LS	1973 LP
120 cm × 22.5 cm	818	1658	1854	2674	1687
120 cm × 30 cm	511	1274	1490	2330	1441
120 cm × 45 cm	563	1337	1677	2469	1462
120 cm × 90 cm	358	784	1184	1996	1166
C.D. at P.05	120	293	308	302	271
C.V. %	-	27.3	23.3	15.0	22.1

The effect of spacing is significant in all the years. With the exception of 120 cm × 30 cm spacing, the closer the spacing the higher was the yield. The low yield in the 120 cm × 30 cm spacing is due to plot heterogeneity. It is interesting to note that the 120 cm × 90 cm treatment has yielded significantly lesser than all the treatments in all the years.

In another experiment (B 8/2) on jat tea started in 1966 the following results were obtained.

Table 2. Effect of spacing on yield of made tea (kg/ha)

Treatment	1969 LP	1970 DS	1971* MS	1972* LS	1973 LP
120 cm × 120 cm	234	646	964	1547	1042
120 cm × 90 cm	292	714	1146	1724	1115
120 cm × 90 cm ** (doubleton)	329	859	1255	1687	1182
120 cm × 75 cm	276	755	—	—	1094
120 cm × 60 cm	340	855	1260	1859	1198
120 cm × 75 cm × 75 cm	368	1047	1359	1823	1281
C.D. at P.05	79	162	242	N.S.	127
C.V.%	17.0	13.2	13.1	9.3	7.3

*1971 & 1972 analyses were done eliminating the 120 cm × 75 cm treatment where yields were very poor due to plot heterogeneity.

**Two plants planted in one hole.

In this experiment also 120 cm × 75 cm × 75 cm and 120 cm × 60 cm spacings have given higher yields than 120 cm × 75 cm, 120 cm × 90 cm and 120 cm × 120 cm spacings.

Bringing Young Tea into Bearing.

An area was planted with Clone T.V. 9 in August, 1968 in single hedge of 120 cm × 60 cm and staggered double hedge of 120 cm × 90 cm × 60 cm. This tea was brought up by the low tipping method and plucking and stepping up continued till the 1972 season. This tea was pruned at different heights ranging from 40 cm to 60 cm in January, 1973 to find out the correct height of pruning. It was found that frame development was not satisfactory at any height in the above range. Observations on frame development were published in last year's Annual Report. The yield from the different treatments was recorded and is given in Table 3.

Table 3. Effect of different pruning heights on the yield of made tea in kg/ha.

Spacing	1972 yield	Pruning height in January 1973	Yield in 1973
120 cm × 60 cm	2322	60 cm	2184
		52.5 cm	1932
		45 cm	1598
120 cm × 90 cm × 60 cm	2162	60 cm	1963
		55 cm	1898
		50 cm	1821
		45 cm	1702
		40 cm	1574

These data are from small unreplicated plots but they nevertheless bring out the relationship between height of pruning and yield.

Stump Planting of Tea

This experiment was started in 1968 to compare bheti planting with stump planting. Details about this trial have been published in 1971-72 Annual Report. The results from 1970 onwards are recorded in Table 4.

Table 4. Yield of made tea in kg/ha.

Time of Planting	Treatment	Made tea in kg/ha			
		1970	1971	1972 DS	1973 MS
April/May	Bheti Planting	283	1114	2178	2020
	10 cm Stump Planting	249	1646	1472	1996
	22 cm Stump Planting	216	1547	1513	1896
September/ October	Bheti Planting	200	956	2129	2170
	10 cm Stump Planting	183	1397	1463	1904
	22 cm Stump Planting	116	890	1164	1630

The pruning treatment given to stumps was different from the treatment given to *bheti* plants. After planting in 1968 the stumps were allowed to grow unchecked in 1969. They were cut across at 37.5 cm in July 1970 and plucked at 30 cm measure. The bushes were left unpruned in 1971 and deep skiffed at 53 cm in January '72 and medium skiffed in January 1973. The *bheti* plants were kept tipped at 80 cm in 1969 and were given a decentre and cut across at 45 cm in January, 1970 and plucked at 80 cm ground measure. They were cut across at 45 cm and recentred in January 1971 and deep skiffed at 65 cm and medium skiffed in 1972 and 1973 season respectively.

Plucking

The results of the plucking experiment started in 1971 have been reported earlier. The 1973 results along with previous results are recorded in Table 5.

Table 5. Effect of plucking methods on yield of made tea (kg/ha).

Treatments	Without broken back leaf			With broken back leaf		
	1971 MS	1972 LP	1973 UP	1971 MS	1972 LP	1973 UP
T_1 —Pluck black to janam	2149	1851	2701	—	—	-
T_2 - Pluck standard leaf no breaking back	1454	1325	1948	- -	—	—
T_3 —Pluck standard leaf and break back to janam	1558	1312	1623	2000	1838	2338
T_4 - Pluck standard leaf over fish leaf no breaking back	1273	1169	1708	— -	—	—
T_5 —Pluck standard leaf on fish leaf, break back to level off	1487	1240	1721	1896	1617	2214
C.D. at P.05	115	131	174	134	134	163
C.V. %	5.3	6.9	6.5	5.6	6.2	5.4

In treatments 3 and 5 the broken back leaf was recorded separately. Yield comparisons between treatments with and without broken back leaf are given in the table above. In 1971 and 1973 black to janam plucking gave significantly higher yield than standard janam and fish leaf pluckings which were *at par*. In 1972 which was the pruned year, black and janam plucking were *at par* and fish leaf plucking yielded significantly less.

The experiment was plucked on a seven day round throughout. The broken back leaf as per cent of the total monthly harvest for T_3 and T_5 is shown in table 6. This gives a rough indication of the rate of growth.

Table 6. Per cent broken back leaf in different months.

Treatments		March	April	May	June	July	August	September	October	November
T_3	1972 (LP)	—	—	37	38	38	34	21	18	10
	1973 (UP)	20	37	42	29	29	36	29	19	9
T_5	1972 (LP)	—	—	33	30	29	27	23	18	1
	1973 (UP)	17	13	30	28	25	24	22	15	11

Manuring

A number of experiments on different aspects of manuring are being conducted at Borbhetta. The results of some of these experiments are briefly discussed below.

Experiment No. B 43 : This experiment, started in 1930, on 1922 planted tea, was one of the earliest efforts at finding out the manurial requirement of tea through a statistically designed field experiment. This experiment is still continuing but the tea is more than 50 years of age with a lot of vacancies. The details of this experiment will be published elsewhere but the broad conclusions arrived at after a combined analysis of the data on a computer upto 1967 and subsequent results upto 1973 are briefly given below.

In this experiment nitrogen was applied as 2:1:1 N.P.K. mixture. The response curve based on the average yield of 1930-39 shows a linear dose yield relationship upto 135 kg N/ha in the form of 2:1:1 mixture, which was the highest dose applied.

The fertilizer dose was increased and the data during 1940-58 showed response to 180 kg N/ha as 2:1:1 mixture. No further response was obtained to 224 kg/ha.

The pooled analysis of the data for 45, 90 and 135 N applications for 1930-58 showed that N_{135} was significantly better than N_{90} which in turn was significantly better than N_{45}. There was no difference between single and divided doses.

Shade was planted in four replications in 1959 but the favourable effect of shade on treatments was noticeable only from 1964 onwards possibly due to the fact that shade was not adequate to influence response. During 1959-67 highest yield was recorded in treatment N_{90} P_{45} K_{45} followed by N_{45} $P_{22\cdot5}$ $K_{22\cdot5}$ treatments irrespective of whether applied in one dose or divided doses. The treatments with higher doses of nitrogen upto 224 kg/ha were *at par* with 90 kg/ha. The lack of response to higher doses of nitrogen may be related to the older age of the tea bushes during this period.

In the 1930-39 as well as 1940-58 period, response to higher doses was obtained but in the 1959-67 period no response was obtained beyond 90 kg N/ha.

Experiment B 8/1: In another experiment at Borbhetta where 100, 200 and 300 kg/ha nitrogen levels were tried on clonal tea planted in 1966 significant increase in yield due to application of 200 kg N/ha was recorded in 1971 and 1972. The increase in yield in 1973 which was the pruned year, did not reach the level of statistical significance.

In another experiment (B 113.1) on the effects of level and frequency of application of nitrogen on the yield of jat tea, no significant increase in yield was obtained as a result of increasing the dose from 90 kg/ha to 135 kg/ha and also by splitting it in 2, 3 and 4 applications. The yield data are tabulated in Table 7.

Table 7. Mean yield of made tea in kg/ha.

Treatments	1967-69 LP-DS-MS	1970-72 LP-DS-MS	1973 LP
90 kg N/ha in one dose	1712	2386	1993
90 kg N/ha (45 × 2) in two applications	1780	2416	2124
90 kg N/ha in 4 splits	1753	2281	2032
135 kg N/ha in one dose	1777	2481	2063
135 kg N/ha in two splits	1825	2348	1970
135 kg N/ha in three splits	1843	2409	1985
135 kg N/ha in 4 splits	1815	2446	2101
C.D. at P.05	N.S.	N.S.	N.S
C.V. %	5.0	5.2	5.4

Phosphate Manuring

In one experiment where phosphate has been applied as superphosphate from 1960 at 0, 45, 90 and 180 kg P_2O_5 per hectare on Clone T.V.2, it showed a depressing effect on crop upto 1970. The trend of response to phosphate application has reversed from 1971 (Fig. 1) and application at upto 90 kg/ha has shown a slight increase in crop which has however, not reached the level of statistical significance. The reversal in the trend of response may be related to adoption of chemical weed control in this area and consequent development of a mass of feeder roots in the top layer of the soil.

FIG. 1. EFFECT OF DIFFERENT LEVELS OF PHOSPHATE ON YIELD.

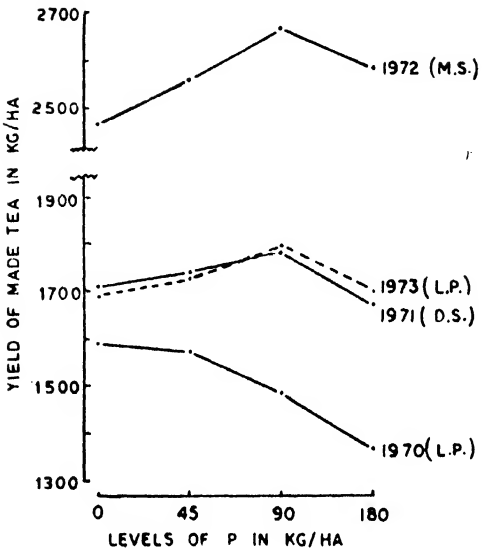


Fig. 1

Another experiment (B 23/3) was started in March 1973 to study the effect of mulch and chemical weed control on response of phosphate fertilisation. The results are given in Table 8.

Table 8. Yield of made tea in kg/ha.

Treatments		1973 LP
Phosphate	No. P	1468
	50 kg/ha	1474
	100 kg/ha	1463
	150 kg/ha	1506
	200 kg/ha	1480
Mulch	No Mulch	1480
	Guatemala mulch	1477
Weed Control	Cheel	1483
	Chemical Weed Control	1473
	C.D.	N.S.
	C.V. %	8.5

The results show no effect of phosphate application at doses ranging from 50 kg/ha to 200 kg/ha even in the presence of mulch and weed control. These results do not conform to the results obtained in B 105. This being the first year of the experiment, no conclusions can be drawn.

Potash Manuring

In one experiment where potash has been applied from 1960 at 0, 45, 90 and 180 kg/ha on Clone T.V.2 the response to potash has shown some interesting trends. The mean yields during the last two pruning cycles are given in Table 9.

Table 9. Yield of made tea in kg/ha.

Treatments	1967-69 LP-DS-MS	1970-72 LP-DS-MS	1973 LP	Response/kg K_2O 1967-69	Response/kg K_2O 1970-72
No. Potash	1181	1686	1495	—	—
45 kg/ha	1311	1931	1779	2.9	5.4
90 kg/ha	1430	2019	1803	2.6	2.0
180 kg/ha	1590	2114	1854	1.8	1.0
c.d. at p.05	132	115	106		
C.V. %	13.5	8.3	8.6		

The above results indicate that yield increased with increasing doses of potash in both the cycles. But there is clear indication that response to higher levels of potash went down in the second cycle. There was a significant difference between 45 kg and 180 kg per hectare rates of application in 1973. This suggests that after a certain number of years when the potash level in the soil and the plant was built up, application of a maintenance dose of potash was adequate for sustained yields.

Micronutrients

Zinc : The results of the experiment (B 108.1/2) started in 1970 where Zinc sulphate was applied on 16 year old Betjan tea at the rate of 24 kg/ha in 4 splits of 6 kg/ha at bimonthly intervals are recorded in Table 10.

Table 10. Yield of made tea in kg/ha.

Treatments	Made tea in kg/ha 1971 (UP)	1972 (LP)	1973 (DS)	No. of Shoots/kg 1971	1972	1973
Zinc Sulphate	2383	1932	2117	1968	1430	1734
Water Spray	2204	1756	2016	1983	1402	1737
't' test	Sig.	N.S.	N.S.	—	—	—
C.V. %	9.2	15.0	14.7	—	—	—

Significant response to application of Zinc sulphate was recorded in 1971 only. The increase in 1972 and 1973 did not reach the level of significance. This could be due to the fact that 1972 and 1973 were pruned and deep skiffed years and 1971 was an unpruned year. Shoot size has not been affected by application of Zinc sulphate in any of the three years.

Another experiment on Clone T.V. 9 was started in 1973 to determine the level (12.5 & 25 kg/ha), method (soil and foliar), and frequency (annual and once in 3 years), of application of Zinc sulphate on mature tea. 1973 was the light pruned year. The experiment has to be continued for a period of at least three years to get the information on the above aspects.

Effect of Zinc on quality : Leaf from B 108/1.2 was manufactured in one kg rollers on 22 occasions by C.T.C. method. The results of tasting are given in Table 11.

Table 11.

Treatments	Strength	Quality	Valuation
Control (water spray)	66	63	6.18
Zinc sulphate (foliar)	62	57	5.90
C.D. at P.05	N.S.	N.S.	N.S.

The differences were not statistically significant.

Long Term Agricultural Trial of Tocklai Clones

To study their yield performance, a long term agricultural trial was started with Tocklai release clones which were planted in 1966-67. The yield data of these clones for the years 1972 and 1973 are recorded in Table 12.

It is too early to draw conclusions on the yield performance of different clones. Proper comparisons will be possible after the completion of one pruning cycle.

Table 12. Yield of made tea in kg/ha.

Clone	Made tea in kg/ha	
	1972 (MS)	1973 (LP)
T. V. 1	1549	1782
T. V. 2	1275	1205
T. V. 4	1742	1912
T. V. 6	1061	1122
T. V. 7	1691	1935
T. V. 8	1589	1653
T. V. 9	1604	1988
T. V. 10	1782	1859
T. V. 11	1734	1931
T. V. 12	1187	1577
T. V. 13	1176	1311
T. V. 14	1908	1976
Betian	1600	1530
C. D. at P. 05	236	310
C. V. %	10.6	12.9

The made tea yields of other clones is also given in Table 13.

Table 13 Yield of made tea in kg/ha.

Clone	Year of planting	1972	1973
T. V. 15	1967	783	1698
T. V. 16	1966	1650	1955
T. V. 17	1969	754	1649
T. V. 18	1969/70	915	1644
T. V. 19	1969/70	1351	1874
Stock 450	1967	1616	1816

The above data cannot be statistically analysed because all the four plots were not planted at the same time.

Chemical Weed Control

Roundup :

Roundup was received at Borbhetta in 1972 for trials. Exploratory trials indicated it to be a very promising herbicide and detailed trials were conducted in 1973 at Borbhetta and also in 12 tea estates scattered all over N.E. India. The estate trials showed it to be a very satisfactory herbicide particularly for the control of *Imperata cylindrica*. Its specific effect against important individual weeds is recorded below.

Borreria hispida : Good control was obtained at the 6 lits/ha dose. Lower doses were not very effective.

Commelina benghalensis : Roundup was quite effective at 6 lits/ha dose but control was not complete.

Imperata cylindrica : Control was complete at the 6 lits/ha dose. Good control was obtained at the 3 lits/ha dose but some plants were not completely killed and started regrowth.

Paspalum conjugatum : Good control was obtained at 3 lits/ha dose.

Paspalum scrobiculatum : Good control was obtained even at 1.5 lits/ha dose in 1973. It was not effectively controlled in 1972.

The following weeds were found partially resistant to Roundup: *Arundinella benghalensis, Colocasia antiquorum, Hydrocotyle rotundifolia, Mimosa pudica, Pteridium aquilinum* and *Urena lobata*. It might be mentioned that except *Pteridium aquilinum* none of the latter group are a major problem in tea at present.

Phytotoxicity studies indicate that Roundup is very safe for use in tea because of its negligible toxicity to tea.

Effect of Roundup on Quality of Tea

Leaf from a plot receiving Roundup was manufactured on 16 occasions and compared to the tea from a cheel plot. Roundup did not have any adverse effect on the strength, quality and valuation.

Field studies on other herbicides are continuing.

Control of *Oxalis acetosella*

TOK E-25 was tried at 2, 4 and 6 lits/ha along with Gramoxone + Karmex cocktail and cheel. None of the treatments were entirely satisfactory but the best control was obtained by using TOK E-25 at 6 lits/ha. The first spray controlled Oxalis for 10 days but subsequent sprays could control it for 5—6 weeks. 35 per cent of the bulbils were also dead against 11 per cent in the cheel and 8 per cent in the control plot. The second best treatment was Gramoxone 1 lit + Karmex 4 kg/ha.

Control of *Colocasia antiquorum*

TOK E-25, Ansar 529, 2,4-D, Dalapon, Gramoxone, Probe and Roundup were tried against *Colocasia* and all except TOK E-25 were tried against Ferns. Only TOK E-25 could control *Colocasia* and the highest dose of 6 lits/ha was most effective. None of the herbicides could effectively control ferns.

Ammonium Sulphamate

Ammonium sulphamate was tried as a post-emergent herbicide at 15, 30, and 60 kg/ha dose in August and September, 1973. Weed control was found to be very poor. However, the growth of weeds was stunted after spraying. Soil application of Ammonium sulphamate did not show any toxic effect on one year old sleeve grown plants whereas the direct spray on the plants at all the concentrations affected the plants.

Basalin & Basagran

The above herbicides were obtained from BASF, Bombay. Basalin is a pre-emergence herbicide and Basagran is a selective contact herbicide for post-emergence weed control. Preliminary trials were conducted and Basalin showed some promise. Further trials are in progress.

BORBHETTA FIELD EXPERIMENTAL ESTATE REPORT

Labour—The average daily attendance of labourers during the current year, compared with the last four years, is as follows :—

Year	No. of labourers engaged
1969 ...	208.63
1970 ...	188.30
1971 ...	179.00
1972 ...	183.00
1973 ...	185.00

Crop—The total yield of green leaf during the current year, compared with the last four years, is as follows :—

Year		Yield
1969	...	1,44,985 kg
1970	...	1,72,868 kg
1971	...	1,74,555 kg
1972	...	2,26,455 kg
1973	...	2,14,882 kg

Out of the above 1973 crop, 2,06,159 kg green leaf was sold to Ducklingia T.E., and the remaining was used for experimental purpose. General plucking was stopped on 7.12.73.

Nanda Devi Seed Bari : 530 kg Nanda Devi seed was supplied to Darjeeling estates from the Borbhetta seed bari.

Vegetative Propagation : The responsibility for distribution of cuttings/scions has been transferred to the Advisory Department, Tocklai with effect from 1973.

Soils and Meteorology Department

SOIL CHEMISTRY

Studies on soil phosphate

(a) **Importance of aluminium phosphate fraction in tea soils :**

Forty soils from the tea growing regions of North East India and, varying in exchangeable aluminium content between trace to 500 p.p.m., were utilised for the purpose of this study. The object was to find out the degree of phosphorus binding by the various soils, as well as to correlate aluminium bound phosphorus with the exchangeable aluminium content of tea soils.

It has been observed that the phosphorus binding capacity of tea soils varies between roughly 20 to 100 per cent depending upon the *native* aluminium saturation of the soils. The relationship between exchangeable aluminium content of soils and the adsorbed or bound phosphorus has been found to be linear (Fig. 1) with a highly significant fit ($P \leqslant 0.001$, $r^2 = 0.82$). Further, phosphorus binding capacity by the soils has not been affected by regional influences.

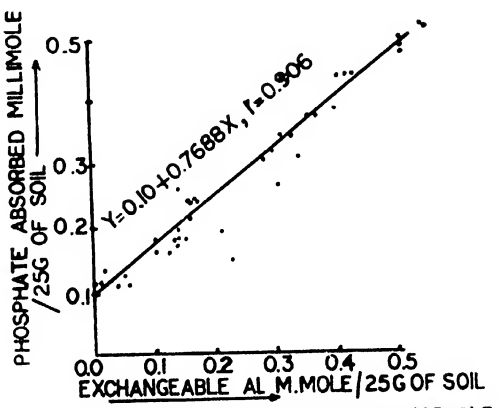


FIG 1: RELATIONSHIP BETWEEN EXCHANGEABLE ALUMINIUM AND BOUND PHOSPHORUS IN TEA SOILS.

The effects of removal of exchangeable aluminium on the phosphorus binding capacity by tea soils have also been examined. For this study a pair of both "high" (450—600 p.p.m. exchangeable aluminium) and "low" (traces) aluminium soils were used. Each of these four soils were given two series of treatments namely,

(i) **Series A treatment :** Exchangeable aluminium content of soil was completely hydrolysed (brought out in the solution phase from the soil complex) by treatment with calcium hydroxide, the object being to ensure completion of binding reaction between the added phosphorus and the aluminium thus hydrolysed;

(ii) **Series B treatment :** Exchangeable aluminium content of soil was completely leached out of the soil-system by repeated percolation of soil (packed in column) with calcium chloride, taking advantage of direct exchange between calcium and aluminium ions.

Each of the above treated soils (both series A and B) was then allowed to react with phosphate by laboratory equilibration method. The method comprises of shaking pre-treated soils (series A and B) with phosphate solution of known concentration (0.5 mili moles of potassium-hydrogen phosphate) for periods of 1, 2, 4, and 6 hours respectively, and subsequently estimating the unreacted phosphorus. From a knowledge of the amount of phosphorus added and the amount of unreacted phosphorus estimated after each shaking period, the adsorbed or bound phosphorus was determined. The experimental results are shown graphically in Fig. 2.

From Fig. 2, it is seen that soils of "high" and "low" aluminium saturation, irrespective of the regions, differed remarkably in their phosphorus binding capacities under series A treatment, i.e., when soil exchangeable aluminium was completely hydrolysed and allowed to react with the added phosphorus (see graphs marked hydrolysed). On the contrary, phosphorus binding capacity of the

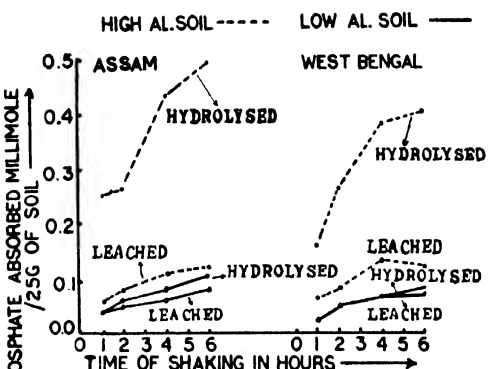


FIG.2: EFFECT OF REMOVAL OF ALUMINIUM ON THE ABSORBED PHOPHORUS BY HIGH AND LOW ALUMINIUM SOILS.

"high" aluminium soils decreased remarkably with the removal of aluminium, whereas phosphorus binding capacity of "low" aluminium soils remained practically unaffected by removal of aluminium (see graphs marked leached).

From the results of this complimentary study, as well as from the observed linear relationship between exchangeable aluminium and the adsorbed or bound phosphorus mentioned earlier, it can safely be concluded that aluminium plays the key role in determining the adsorbtion or so-called "fixation" of soluble phosphatic fertilisers in our acid tea soils. The practical implications of the experimental findings are :

(i) Phosphate adsorbtion or binding capacity of tea soils can be predicted with confidence by the rapid test of exchangeable aluminium content of soils;

(ii) For ensuring instantaneous or even rapid availability of applied phosphorus to tea, a suitable soil treatment has to be evolved by which aluminium can be partially blocked or inactivated from taking part in the phosphorus adsorbtion reaction mechanism;

(iii) By encouraging surface root (feeder root) proliferation and, thereby, directly intercepting the applied soluble phosphorus through roots, the time of contact between the reactive aluminium and the soluble phosphorus (for completion of adsorbtion reaction) can be shortened.

(b) **Phosphate releasing capacity of tea soils (a laboratory study)**

The object of this investigation was to find out whether the bound or the so-called fixed phosphorus releases into soil solution (root sink) over a time span. A few representative tea soils were treated with 0, 60, 120 and 180 kg P_2O_5 /ha, and subsequently the fertiliser treated soils were incubated at a temperature of 30°C using standard procedure. Aluminium-bound phosphorus was estimated at monthly intervals for a period of four months.

With increasing doses of phosphate application, a linear increase in the aluminium bound phosphorus of soils has been observed. Further, with the progress in the period of incubation, a decline in the aluminium bound phosphorus fraction of the soils has been noted. The decline continued for a period of one month for the lower (below 120 kg P_2O_5/ha), and for two months for the higher (above 120 kg P_2O_5 /ha) rates of phosphate applications. The results, therefore, suggest that the aluminium-bound phosphorus is not chemically inert, since bound phosphorus of this particular form releases under the influence of short period of incubation.

Release of aluminium bound phosphorus was studied in another experiment where soils were treated with 0, 120, 240 and 360 kg P_2O_5/ha. Phosphate treated soils in this experiment were incubated under anaerobic (water logged) conditions for a period of one month, as opposed to the aerobic conditions of incubation employed in the previous experiment.

It has been observed that over the one month period of anaerobic incubation aluminium bound phosphorus decreases sharply, and the water soluble phosphorus fraction increases remarkably. Compared to the control, the water soluble phosphorus increased by one and half time with 240 kg P_2O_5/ha

treatment and became almost double with 360 kg P_2O_5/ha treatment. Thus it appears that the release of phosphorus from the aluminium bound phosphorus form into the water soluble (reading available) form is faster under anaerobic conditions than under aerobic conditions.

(c) Aluminium bound or potentially available phosphorus under mulch and weed control

For this purpose Agronomist's long-term trial at Borbhetta was taken advantage of, where mature tea under various mulching and weed control treatments received five levels of phosphate as triple superphosphate. The levels of phosphate application are 0, 50, 100, and 200 kg P_2O_5/ha.

It appears that under field conditions too the aluminium bound phosphorus fraction of soil increases linearly with increasing levels of application of phosphate. The relationship was statistically found to be highly significant ($P \leqslant 0.001$). Further, aluminium bound phosphorus tends to decrease with time. Under mulch treatment, however, aluminium bound phosphorus tends to increase by about 15—20 p.p.m.

Studies on liming

(a) Effect of long-term liming on the physical properties of tea soils

Effect of long-term liming on the physico-chemical changes in soils have been reported last year (see 1972-73 annual report, P. 35—36). Further work has been carried out to find out the effects of the varying levels of liming on the soil structural parameters like aggregate index and bulk density at tri-monthly intervals.

Mean data of the seasons are given in Table 1.

From the above table it is seen that the long-term application of lime has resulted in appreciable improvement of total soil aggregates, especially of those aggregates which are above 2 mm in size dimension. However, very little difference in soil aggregation has been noted between the lime applications at two and four tonnes per hectare.

Mean weight diameter of the soil aggregates under various treatments was also determined by both planimetric (Method A) and computation method, (Method B) the results of which are shown in Table 2.

From table 2 it is seen that the mean weight diameter of soil aggregates determined by both the methods (Methods A and B) increases to about one and half times by long-term liming. Further, mean weight diameter (m.w.d.) values of the different seasons determined by both methods were correlated with an aim to find out whether m.w.d. determined by area measurement (planimetric) method can be predicted with accuracy from the calculated values of mean weight diameter (compu-

Table 1. Changes in soil aggregates due to long-term liming.

Treatments	Percentage aggregates of varying sizes (on dry weight basis)						p.c. total aggregates
	>5 mm	5—2 mm	above 2 mm	2—1 mm	1—0.5 mm	0.5—0.25 mm	
No lime	12.42	24.78	37.20	4.89	4.12	14.12	60.33
Lime @ 2 t/ha	21.11	39.02	60.13	3.45	3.02	10.58	77.18
Lime @ 4 t/ha	22.94	35.67	58.61	3.55	2.95	10.84	75.95

Table 2. Effects of long-term liming on the mean weight diameter of soil aggregates.

Treatment	Mean weight diameter of aggregates in mm (mean of seasons)	
	Method A (by actual measurement)	Method B (by computation)
No lime	1.656	1.819
Lime 2 t/ha	2.521	2.775
Lime 4 t/ha	2.517	2.771

tation method). The linear relationship between methods A and B as shown in Fig. 3, has been found to be highly significant ($P \leqslant 0.001$), the regression equation is, $Y = 0.905\ X + 0.10$, and the correlation coefficient is 0.998.

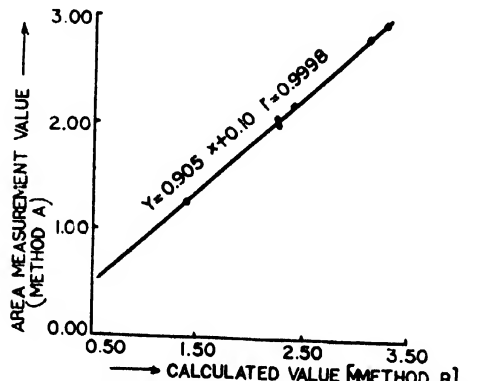


FIG.3: RELATIONSHIP BETWEEN AREA MEASUREMENT VALUE AND CALCULATED VALUES OF MEAN WEIGHT DIAMETER.

The effect of liming on the bulk density of the top soil has not, however, been found to be significant. The absence of any significant effect could be due to the artefact of measurement which needs improvement.

(b) **Effect of liming on the cationic composition, and potassium releasing capacity of tea soils**

Soils were pre-treated with lime at rates 0, 2 and 4 t CaO/ha as slaked lime, and were alternately wetted and dried for attaining stable pH values. Both limed and unlimed series of soils were then treated with potassium at the rates of 0, 100, and 200 kg K_2O/ha, and these were again subjected to a vigorous cycle of alternate wetting and drying (14 times) to allow maximum possible fixation of applied potassium.

The above treated soils were then packed in percolating columns in desired density, and were leached with ammonium acetate until the leachates become free of potassium (about 40 successive leachings). The soils were then taken out of the columns, and both the soil and the leachate were analysed for pH, potassium, and calcium. Results are described below :

(i) **Effect of pre-liming on water soluble (soil solution) potassium**

Mean potassium data as affected by varying levels of lime and potash application are given in Table 3.

Table 3. Effect of liming on the potassium content of soil solution (data expressed as mili equiv. potassium per 100 g soil).

Lime treatment	Potash treatment			Mean of Potash levels
	K_0	K_{100}	K_{200}	
No lime	0.045	0.064	0.119	0.076
Lime at 2 t/ha	0.036	0.049	0.095	0.060
Lime at 4 t/ha	0.023	0.044	0.083	0.051
Mean of lime levels	0.036	0.052	0.099	—

C.D. at 0.1% = 0.024; at 1% = 0.018; at 5% = 0.014

It is seen from table 3 that liming or in other words calcium saturation of soils negatively affects the water soluble potassium fraction. The negative effect has been statistically found to be highly significant ($P \leqslant 0.001$). The increase of water soluble potassium with increasing levels of application of potassium has also been statistically found to be highly significant ($P \leqslant 0.001$). However, the interaction between lime and potassium has been non-significant.

(ii) **Effect of liming on the potassium exchange capacity of soils**

Mean potassium exchange data as affected by varying levels of lime and potash application are given in Table 4.

It is seen from Table 4 that the potassium exchange capacity is also negatively affected by liming. The negative effect has been statistically found to be highly significant ($P \leqslant 0.001$). The interaction between lime and potassium, as before, has been non-significant.

Table 4. Effect of liming on the potassium exchange capacity (data expressed in milli equiv./100 g soil).

Lime treatment	Potash treatment K_{100}	K_{200}
No lime	0.093	0.227
Lime at 2 t/ha	0.078	0.203
Lime at 4 t/ha	0.069	0.189

From the results given under (i) and (ii) above, it is concluded that pre-treatment of lime results in either increased retention of applied potassium, or decreased availability of water soluble potassium fraction (immediately available to roots). However, according to soil potassium dynamics, i.e., K exchangeable $\rightleftharpoons$ K water soluble, which is a continuous process, the additional retained potassium due to liming is likely to maintain the sustained release of potassium to the root sink (i.e. water soluble fraction) for a longer period.

(iii) Relationship between pH and potassium availability

The parameter potassium intensity or $K/\sqrt{ca}$ of the water extract of soils determines the immediate availability of potassium to the root surface according to the energy concept. The aim of this study is to find out whether $K/\sqrt{ca}$ is affected by the changed pH status as a result of liming. The relationships between pH and the $K/\sqrt{ca}$ estimates of the water extract of soils are shown in Figs. 4(a) and

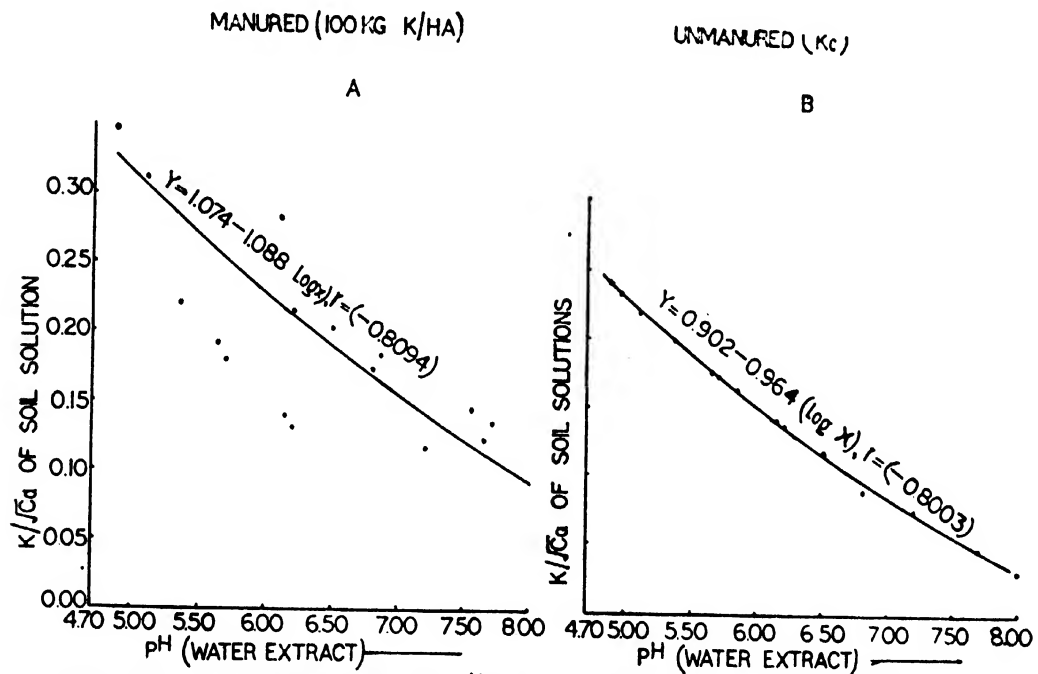


FIG. 4 A & B. RELATIONSHIP BETWEEN pH (WATER EXTRACT) OF SOILS AND $K/\sqrt{Ca}$ VALUES OF SOILS SOLUTION IN SATURATION EXTRACT.

4(b). The negative correlation between pH and $K/\sqrt{ca}$ values has been found to be statistically highly significant ($P0 \leqslant .001$). The regression equations for K_0 and K_{100} series soils are :

$Y = 0.902 - 0.964 (\log \times)$, for the K_0 series..(a)

$Y = 1.074 - 1.088 (\log \times)$, for the K_{100} series..(b)

and the correlation co-efficients (r) for (a) and (b) are — 0.8003 and — 0.8094 respectively.

The practical implication of this finding is that while correcting pH status of acid tea soils with lime, attention should simultaneously be paid to incorporate potassium at higher levels to safeguard against possible impairment of the immediate availability of potassium to the plant roots.

(c) **Effect of liming on the nitrogen releasing properties of soils**

Soil from the long-term liming trial at Cinnamara T.E. have been used for this study. The soils used have the pH values 4.6, 5.2, and 5.9 corresponding to 0, 2, and 4 t/ha lime treatments respectively.

Each of the soils were treated with nitrogen (as S.O.A.) at rates 0, 67, 134 and 201 kg N/ha in the laboratory, and subsequently incubated at 30°C for periods of $3\frac{1}{2}$ and $5\frac{1}{2}$ months under anaerobic and aerobic conditions respectively. During the period of incubation nitrogen releasing characteristics of the soils was studied at fortnightly intervals.

Mean nitrate data for the entire period of aerobic incubation are shown in Table 5.

Table 5. Effect of lime and nitrogen levels on the nitrate release from soils (mean data of eight periods in p.p.m.).

Lime levels	Nitrogen rates				Mean of nitrogen rates
	No nitrogen	67 kg N/ha	134 kg N/ha	201 kg N/ha	
No lime	5	6	8	8	7
Lime at 2 t/ha	9	14	18	23	16
Lime at 4 t/ha	10	20	22	26	20
Mean of lime levels	8	13	16	19	—

From table 5 (last column) it is seen that the nitrate release from acid tea soils under aerobic conditions is doubled with lime application at 2 t/ha and trebled with lime at 4 t/ha irrespective of the rates of nitrogen application. However, in general, the quantum of nitrate-nitrogen released from the soils increases progressively with the increasing rates of nitrogen application, i.e., $N_{201} > N_{134} > N_{67} > N_0$. Further, the higher quantities of release of nitrate-nitrogen from the limed soils compared to unlimed soils remain sustained for a fairly long period, i.e., 5—6 months under aerobic conditions.

As far as the ammonia release under aerobic conditions is concerned, it has been observed that within two weeks from the time of application of nitrogen, release of ammonia attains peak levels in both unlimed and limed soils. Thereafter, ammonia release from the limed soils declines at a much faster rate compared to their unlimed counterparts. For example, under 201 kg N/ha treatment, release of ammonia-nitrogen from the unlimed soils becomes negligible at the end of $3\frac{1}{2}$ months, whereas with lime treatment at 2 and 4 t/ha, release of ammonia-nitrogen practically ceases at the end of 70 and 40 days respectively. Further, release of ammonia-nitrogen increases linearly with the increase in the rates of nitrogen application, and this is true for both limed and unlimed series of soils.

Ammonia-nitrogen release under anaerobic conditions follows exactly the same trends as have been observed under aerobic conditions.

Studies on soil potash

(a) **Non-exchangeable potash**

A large number of soils from the different tea growing regions were treated with a cation exchange resin, viz., Amberlite IR-120 (H), and incubated at 30°C under laboratory conditions for a period of six months for determining the release of potassium from the non-exchangeable source to the available pool at periodic intervals. Soils were selected in such a way as to include almost same numbers of samples with lower and higher quantities of reserve or non-exchangeable potassium (categories above and below 500 p.p.m. level). Results are given in Table 6.

Table 6. Release of available potassium from non-exchangeable source at periodic intervals (data expressed as p.c. increase over control).

Soil Source	Incubation period in months		
	Two	Four	Six
Category I (non-exchangeable K below 500 p.p.m.)	79	129	165
Category II (non-exchangeable potash above 500 p.p.m.)	108	152	234
Mean of I and II	94	140	200

From table 6 it is seen that the release of non-exchangeable potassium increases progressively with the increasing period of incubation. However, soils of categories I and II show a marked difference in the rate of release of non-exchangeable potassium, and this difference very much widens during the later part (4 — 6 months) of incubation period. The release of non-exchangeable potassium from category I soils has been found to be consistently lower than those of category II soils all through the incubation period. It can, therefore, be safely concluded that the quantum as well as the rate of release of potassium from the non-exchangeable source to the available pool is directly linked with the size of the reserve or non-exchangeable potassium rather than the regional soil characteristics.

(b) **Free energies of ion exchange**

Soils were treated with 0, 50, 100 and 200 kg K_2O per hectare in the laboratory, and these were subjected to an alternate wetting and drying cycle for a week to ensure maximum fixation of applied potassium. The treated soils were then utilised for measurement of the changes in free energy and exchangeable potassium due to manuring. The changes in free energy of potassium exchange ($\triangle F$) and exchangeable potassium in both Assam and West Bengal soils maintain highly significant ($P \leq 0.001$) positive correlations, regression equations being:

for Assam, $Y = -4604 + 926.9 \log X$, $r^2 = 0.55$

for West Bengal, $Y = -6877 + 1{,}946.9 \log X$, $r^2 = 0.83$,

where Y and X are the $\triangle F$ and exchangeable potassium values respectively. The relationships for Assam and West Bengal soils are shown in Figs. 5(a) and 5(b) respectively. It is also seen that the

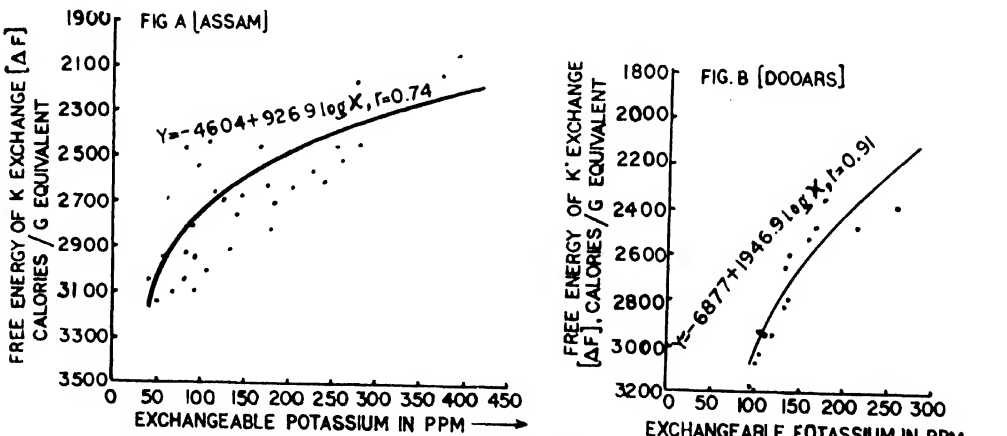


FIG. 5: RELATIONSHIP BETWEEN FREE ENERGY AND EXCHANGEABLE POTASSIUM IN ASSAM SOILS AND WEST BENGAL [DOOARS] SOILS.

rate of change of free energy ($\triangle F$) with unit change in exchangeable potassium (i.e. $\frac{dy}{dx}$) varies appreciably between Assam and West Bengal soils, dy/dx for Assam and West Bengal soils being 926.9 and 1,946.9 respectively. This variation is likely to be caused by the different calcium saturation of Assam and West Bengal soils, viz ., the calcium saturation of Assam soils is twice as much as that of West Bengal soils. In practical terms it means that measurement of the changes in free energy of potassium exchange in both West Bengal and Assam soils may offer a better insight in our soil test—crop correlation studies, since such measurement takes into consideration balanced supply of calcium and potassium to the root surface. With this end in view a rapid routine procedure for measurement of the change in free energy ($\triangle F$) has been developed, where $\triangle F$ is determined at a constant supply of calcium ($\triangle F\ CaCl_2$) instead of determining $\triangle F$ at native saturation of calcium ($\triangle F_{S.E.}$). The highly signi-

ficant ($P \leqslant 0.001$) linear relationship between $\triangle F$ S.E. and $\triangle F\ CaCl_2$ is shown in Fig. 6, the regression equation being.

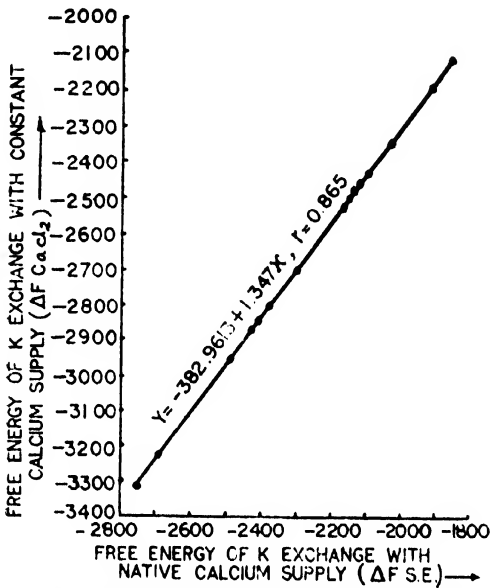


FIG. 6: RELATIONSHIP BETWEEN ΔF $Cacl_2$ AND ΔF S.E. IN TEA SOILS FROM BOTH ASSAM AND WEST BENGAL

$Y = -382.9613 + 1.347\ X$, $r^2 = 0.75$,

where Y and X represents $\triangle F\ CaCl_2$ and $\triangle F$ S.E. respectively. This relationship now allows us to obtain rapidly and reliably $\triangle F$ S.E. values as a function of those of $\triangle F\ CaCl_2$.

(c) Release and Fixation of exchangeable potassium as affected by water

In order to find out the influence of soil moisture on the exchangeable potassium content of soils an experiment was carried out where few soils were allowed to dry out from water-logged condition (30—35 p.c.) to hygroscopic moisture levels (1-2 p.c.). During this process exchangeable potassium content of soils was determined at various stages of drying. The changes of exchangeable potassium with moisture content of soils are shown in Fig. 7. It is seen

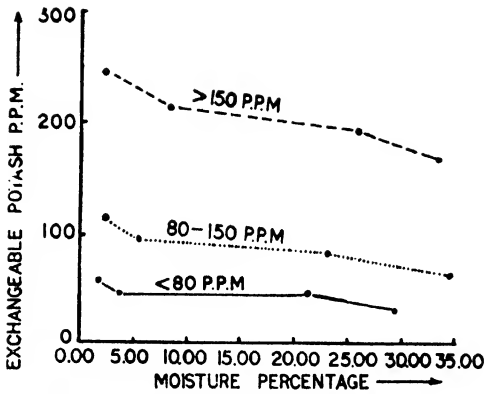


FIG. 7: EFFECT OF DRYING ON EXCHANGEABLE POTASSIUM OF THE SOIL.

from Fig. 7 that exchangeable potassium decreases with the increasing soil moisture contents irrespective of the levels of native potassium in the soils. When soils were dried below 5 p.c. moisture, a very sharp increase in exchangeable potassium has been marked with decreasing moisture levels.

Studies on soil nitrogen

A laboratory experiment has been carried out to find out the effects of neem cake on the nitrogen releasing characteristics of acid tea soils by blending neem cake with common nitrogenous fertilisers like S.O.A. and Urea. The treatments included are as follows :

A. Nitrogen source Urea	B. Nitrogen source Sulphate of Ammonia
T_1 : Control (no nitrogen)	T_1 : Control (no nitrogen)
T_2 : 66 kg neem cake/ha	T_2A : 147 kg neem cake/ha
T_3 : 80 kg N/ha + 36 kg neem cake per ha.	T_3A : 80 kg N/ha + 80 kg neem cake/ha.
T_4 : 80 kg N/ha	T_4A : 80 kg N/ha
T_5 : 160 kg N/ha + 72 kg neem cake per ha	T_5A : 160 kg N + 160 kg neem cake/ha.
T_6 : 160 kg N/ha	T_6A : 160 kg N/ha
T_7 : 200 kg N/ha + 89 kg neem cake/ha	T_7A : 200 kg N + 200 kg neem cake/ha
T_8 : 200 kg N/ha	T_8A : 200 kg N/ha

Neem cake at twenty per cent by weight of fertilisers (under each treatment) was used for blending. Finely powdered neem cake was mixed thoroughly with the fertilisers two days before application so as to ensure uniform blending.

The soils after treatment with blended urea and sulphate of ammonia (as per details given above) were incubated at 30°C according to standard procedure. Ammonia and nitrate nitrogen were estimated at fortnightly intervals for a period of little above three months.

It has been observed that both nitrification and ammonification processes virtually remain unaffected by the use of neem cake blended urea at all levels of nitrogen application in this experiment. Ammonia and nitrate peaks, at all the levels of nitrogen application, have been observed at the end of two and six weeks respectively both in the case of neem cake blended and straight urea, thereby, showing no inhibitory effect of neem cake on the nitrification process. In general, nitrate release remains sustained between the sixth and twelvth week, but the ammonia release steadily declines over the same period, and this is true for both blended and straight urea.

In case of sulphate of ammonia also nitrate release remains unaffected due to blending with neem cake. However, release of ammonia nitrogen from neem cake blended sulphate of ammonia has been consistently found to be higher for all levels of nitrogen application compared to the unblended sulphate of ammonia. Higher ammonia release from blended sulphate of ammonia has been marked up to eight weeks for lower levels of nitrogen application and up to fourteen weeks for higher levels of nitrogen application. The reason for higher quantities of release of ammonia-nitrogen from neem cake blended sulphate of ammonia compared to straight sulphate of ammonia is not known, but it can be concluded that the nitrification process in our acid tea soils remains unaffected by neem cake blending irrespective of the forms of nitrogen used in this experiment.

Cation exchange capacity (C.E.C.) of clonal tea roots

(a) **Effect of forms and levels of nitrogen on the root C.E.C. and ionic balance**

The experiment was carried out in sand culture in glass house with the following nitrogen treatments:

Treatments	Forms of nitrogen	Levels of nitrogen
T_1	Sulphate of ammonia	10 m.e./pot
T_2	Ammonia nitrate	,,
T_3	Urea	,,
T_4	Sulphate of ammonia	20 m.e./pot
T_5	Ammonia nitrate	,,
T_6	Urea	,,
T_7	Sulphate of ammonia	30 m.e./pot
T_8	Ammonium nitrate	,,
T_9	Urea	,,

Six months old clonal cuttings (TV_1 and TV_{18} with highest and lowest root C.E.C. respectively) were transplanted in the pots, and when plants have fully established they were fed initially with Hewitt's nutrient solution (pH 3.5) at quarter strength for a period of $2\frac{1}{2}$ months. Nitrogen treatments were then imposed and plants were allowed to grow for a period of six months after transplanting. According to the treatments nitrogen was supplied daily along with Hewitt's full strength of all other nutrients in solution. Plants were harvested at the end of the six months period.

Above-ground portions were used for the determination of total metal cations (Ca^{++}, Mg^{++}, K^+, and Na^+) and the total metal anions ($H_2PO_4^-$, NO_3^-, SO_4^{--}, and Cl^-), and their root counterparts were used for measurement of C.E.C. and nitrogen.

(i) **Influence of N on root C.E.C.**

Results are shown in Table 7 A :

Table 7A. Influence of rates and forms of nitrogen on the C.E.C. of clonal roots.

Nitrogen Form	Nitrogen rate	Root C.E.C. (in m.e./100 g)	
		Clone TV_1	Clone TV_{18}
Sulphate of ammonia	10 m.e./plot	20.80	14.42
Ammonium Nitrate	,,	21.64	15.20
Urea	,,	20.96	14.68
(Mean of forms)	,,	(21.13)	(14.77)
Sulphate of ammonia	20 m.e./plot	21.46	14.98
Ammonium nitrate	,,	22.08	16.02
Urea	,,	21.64	15.46
(Mean of forms)	,,	(21.73)	(15.49)
Sulphate of ammonia	30 m.e./plot	21.86	16.53
Amonium nitrate	,,	22.60	17.32
Urea	,,	22.52	16.89
(Mean of forms)	,,	(22.33)	(16.91)

From the above table (mean of forms) it is seen that root C.E.C., irrespective of clones and forms of nitrogen, increases with increasing levels of nitrogen treatment. This increase of root C.E.C. is explanable in terms of increased production of white roots with increasing levels of nitrogen application. Highly significant positive correlations ($P \leqslant 0{\cdot}01$) have been found between root C.E.C. and the root or the top nitrogen. For clone TV_1, correlation co-efficient was found to be 0.87 between root C.E.C. and the nitrogen content of both top and root, whereas for TV_{18} correlation co-efficient have been found to be 0.86 and 0.89 for root and top nitrogen, respectively.

(ii) Influence of nitrogen on the uptake of cations

Calcium concentration of the plant tops progressively increases with increasing levels of nitrogen application, whereas the reverse is true for potassium. Sodium and magnesium contents of plant tops remain practically unaffected. This is true for all the forms of nitrogen.

Further, it is interesting to note that the increase in calcium uptake or the decrease in potassium uptake (as a result of increased levels of N manuring) are well correlated to C.E.C. of clonal tea roots. Correlation co-efficients between $K/\sqrt{Ca}$ uptake values and the root C.E.C. have been found to be highly significant($P \leqslant 0{\cdot}01$) for both clones (for TV_1, $r = 0.96$, and for TV_{18}, $r = 0.98$).

An additional point of interest is that in spite of the changes in calcium and potassium concentrations of plant tops due to increasing levels of nitrogen manuring, the total cationic concentration remains constant.

(iii) Relationship between N levels, organic acid production and root C.E.C.

Organic acid accumulation can be indirectly measured by finding out the difference between sum of cations ($Ca^{++} + Mg^{++} + Na^{+} + K^{+}$) and the sum of anions ($H_2PO_4^{-} + SO_4^{--} + NO_3^{-} + Cl^{-}$) in the plant tissues. The same indirect method was used for the determination of organic acids in plant tops.

Irrespective of the forms and clones, organic acid of plant tops, like root C.E.C., increases with the increasing levels of nitrogen application, and both the increases are well correlated ($P \leqslant 0.01$). The regression equations and 'r' values are as follows :

For TV_{18}, $Y = 36.03 + 1.0567 \times$, 'r' $= 0.86$; and
for TV_1 $Y = 31.06 + 1.1126 \times$, 'r' $= 0.87$,

where $\times$ = cation exchange capacity of roots and Y = organic acid content of plant tops. It may be inferred that the increase in organic acid can result in providing additional exchange sites on the root surface for effecting an increase in root C.E.C.

(iv) Nitrogen recovery by clonal plant

Nitrogen recovery by the young clonal plants was also measured in this experiment, results of which are presented in Table 7 B.

Table 7 B. Recovery of nitrogen by young clonal plants from different sources and levels of nitrogen application.

Nitrogen Form	Nitrogen applied (m.e./plant)	Nitrogen recovered (m.e. per plant)		Percentage recovery	
		TV_1	TV_{18}	TV_1	TV_{18}
Ammonium Sulphate	10	7.76	9.16	77.60	91.60
Ammonium nitrate	,,	7.84	9.29	78.40	92.90
Urea	,,	7.25	8.40	72.50	84.00
Ammonium Sulphate	20	8.21	9.72	41.05	48.60
Ammonium nitrate	,,	8.66	10.48	43.30	52.40
Urea	,,	8.62	9.53	43.10	47.65
Ammonium Sulphate	30	9.72	10.93	32.36	36.39
Ammonium nitrate	,,	9.91	11.32	33.00	37.69
Urea	,,	9.02	10.72	30.03	35.69

From table 7B, it is seen that percentage recovery of nitrogen decreases with increasing levels of nitrogen application and this is true for all the forms of nitrogen used in this experiment. At moderate level of manuring, i.e. 20 m.e./bush, the recovery works out to be, on an average, 40 and 50 percent for clones TV_1 and TV_{18} respectively.

(b) Calcium-potassium balance and growth of clones differing in root cation exchange capacity

An experiment was carried out in sand culture under glass house conditions, where both TV_1 and TV_{18} clonal cuttings (six months old) were grown in Hewitt's nutrient solution but having varying supply of calcium and potassium in different permutations and combinations. The experiment was carried out for a period of six months, at the end of which plants were harvested, the above-ground portion was utilised for the determination of calcium and potassium uptake and the root system was used for C.E.C. determination.

The dry matter data suggest that the genetically extreme clones may have different calcium potassium requirement for attaining maximum growth. As far as this Ca: K balance is concerned, a rough and ready guideline can be Ca: K requirement as 1:1 for clones having higher root C.E.C. (China or hybrid type) and 1: 2 for clones having lower root C.E.C. (Assam type).

Calcium and potassium uptake measurements showed appreciably higher uptake of calcium and lower uptake of potassium by the TV_1 plants compared to those of TV_{18} plants under varying levels of calcium and potassium supply in the nutrient solution. The varying levels of Ca: K supply, however, showed no significant affect on the root C.E.C. of both the clones.

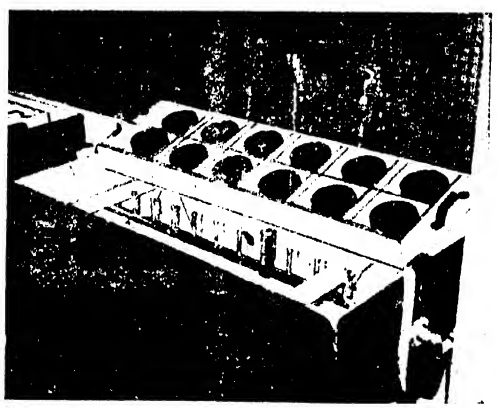
Distribution of roots under regimes of weedicide and mulching

For this investigation Agronomy Department trial on the phosphate response under mulch and weed control has been taken advantage of. A core sampler has been designed as shown in photo 1.

Core Sampler

The sampler has been found to be efficient for taking undisturbed cores from the field of dimensions 9.5 cm in diameter and 7.5 in height. Core sampling technique has been accepted for assessment of root growth in top 7.5 cm layers. Preliminary results showed that eight cores per 60 bush (0.005 ha) plot yield sufficiently accurate results.

For washing the roots contained in the core, a washing assembly has also been designed (see photo 2), which



Washing Assembly

can wash 24 cores simultaneously in one man day. Root cores are now being collected at bi-monthly intervals, and the density of the surface roots in one hectare 7.5 cm soil layers under the influences of chemical weeding and mulching is estimated. Mean data of two epochs of sampling are shown in Table 8.

Table 8. Influence of mulching and weedicide on the density of surface roots (mean data from two epochs of sampling expressed as Kg/ha 7.5 cm soil).

Treatments	Periods of sampling		
	March	May	Mean
Mulch	1,089	1,034	1,062
No mulch	848	652	750
No Weedicide	1,063	860	962
Weedicide	875	826	850

These exploratory data reveal that mulching results in increasing surface root production by about 40 p.c., whereas weedicide treatment does not seem to affect surface root production. Further work is in progress.

Moisture depletion pattern under different spacings of tea

This investigation was carried out with the co-operation of the Manager, Meleng T.E. This estate was chosen for the study, since variously spaced tea of same age and kind have been made available to us. The spacings chosen are:

In series A fields : 120 cm × 90 cm × 60 cm (4′ × 3′ × 2′) 120 cm—60 cm × 60 cm × 60 cm (4′—2′ × 2′ × 2′), and 22.5 cm × 22.5 cm (9″ × 9″) giving plant populations of 12,000, 20,000, and 1,30,000 per hectare respectively.

In series B fields : 50 cm × 50 cm (20″ × 20″) and 30 cm × 30 cm (12″ × 12″) giving plant populations of 33,000 and 1,00,000 per hectare respectively.

All these fields are now carrying tea of age group between 5 6 years. Moisture depletion pattern was studied during the period February to June regularly at weekly intervals. Results are shown in Figs. 8A and 8B. From the figures it is seen that the moisture depletion under high plant population like 1,00,000 and 1,30,000, i.e., 12″ × 12″ and 9″ × 9″ spacings respectively, is appreciably and consistently higher than all other spacings tried out in this study. It has also been observed that, in general, series B fields (8B), which are relatively heavier in texture and richer in organic matter content, maintained a higher level of moisture compared to the series A fields (8A) throughout the experimental period. The basic differences in soil characteristics justify the treatment of the results under 8A and 8B seperately.

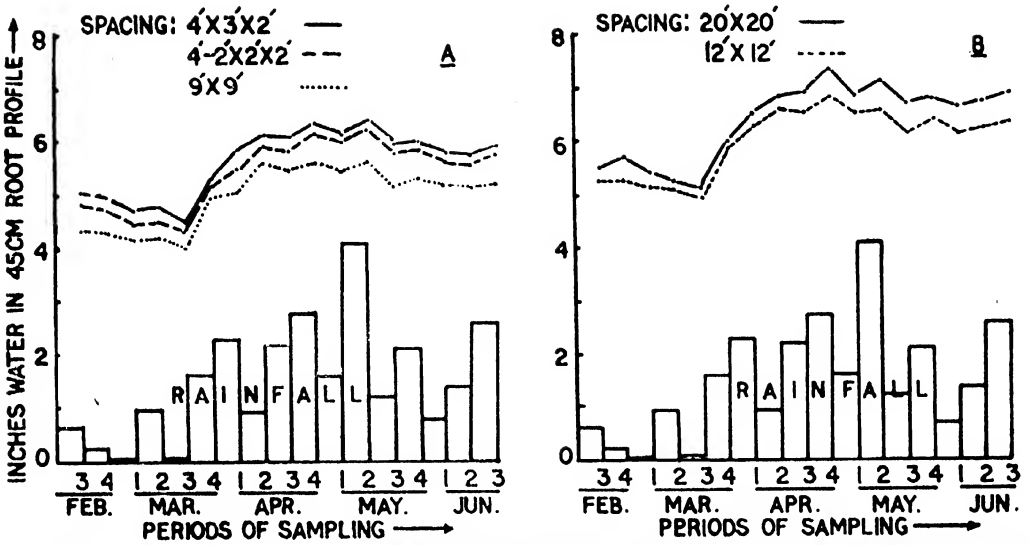


FIG. 8 A&B: CHANGES IN SOIL MOISTURE CONTENT AS INFLUENED BY SPACING OF TEA.

Residue tests for herbicide Ansar 529

Arsenic residue in tea and soil due to application of herbicide Ansar 529 (MSMA) was analysed at Tocklai and WARF Laboratories, U.S.A. Some reports have already appeared in Tocklai publications (Annual Scientific Report 1972-73 pages 23 and 40: Notes and News in Two and A Bud Vol. 21, No. 1, June 1974, pages 24-25). A summary of all the available analyses results for arsenic residue from Ansar 529, in soils, green leaf and made tea, under experimental and commercial conditions, is given below.

Note : Analyses by WARF Institute Inc., Madison, Wisconsin are identified by an asterisk (*).

I. BACKGROUND DATA ON THE ARSENIC CONTENT OF TEA.

A. Background data for North East India :

Table 9. Natural arsenic content of North East India made teas.

Region	P.P.M. arsenic content in made tea of different seasons			
	First flush	Second flush	Rain	Autumnal
Cachar	0.18	0.05	0.05	0.05
Dooars	0.05	0.05	0.06	0.05
South Bank	0.05	0.06	0.05	0.05
Darjeeling	0.05	0.05	0.05	0.08
North Bank	0.05	0.05	0.05	0.05

***B. Background data for South India :**

Table 10. Natural arsenic content of South India made teas.

Region	Kind of tea	Arsenic content in P.P.M.
Wynad	Leaf tea	0.05
Wynad	Tea dust	0.05
Annamalai	Leaf tea	0.05
Annamalai	Tea dust	0.05
Peermade	Leaf tea	0.05
Peermade	Tea dust	0.05
Munnar	Leaf tea	0.05

*C. **Background data for Sri Lanka :**

Table 11. Natural arsenic content of Sri Lanka made teas.

Region	Kind of tea	Arsenic content in p.p.m.
Uva	BOP	0.05
,,	BOPF	0.05
Kandy	BOP	0.05
,,	BOPF	0.05
Dickoya	BOP	0.05
,,	BOPF	0.05
Shelf tea	Brookebond (Red Label)	0.05
Dimbulla	BOP	0.10
,,	BOPF	0.18
Ratnapura	BOP	0.13
,,	BOPF	0.26
Dolosbage	BOP	0.05
,,	BOPF	0.05
Maskeliya	BOP	0.05
,,	BOP	0.05
Dimbulla	BOPF	0.09
Ratnapura	BOP	0.08
,,	BOPF	0.11
Dolosbage	BOP	0.20
Shelf tea	Brookebond (supreme)	0.05

*D. **Background data for Commercial tea (purchased at random in New York) :**

Table 12. Natural arsenic content of commercial teas exported to U.S.A.

Brand and type	Arsenic content in p.p.m.
Lipton's "Yellow label" tea	0.05
,, Tea Bags	0.05
Brooke bond "Red label"	0.05
,, ,, "Hotel blend"	0 05
Mainland China Oolong	0.18
,, ,, ,,	0.14
Japan Green — basket fired	0.55
,, ,, ,, ,,	0.53
Java Flowery — Orange Pekoe	0.05
,, ,, ,,	0.05
Congo tea	0.05
,, ,,	0.05
Formosa —Oolong Superior	0.16
,, ,, ,,	0.29

* Analysed by the WARF Institute INC., Madison, Wisconsin

II. Arsenic residue in short-term (UPASI) trial with Ansar 529 :
Experiment No. 1.

Table 13. Residue data from 1971 UPASI trial.

Treatment	Tea plucked and mini-manufactured p.p.m. arsenic residue		
	Pre-treatment	7 days after treatment	21 days after treatment
Control	0.05	0.05	0.10
Ansar (2 lit/acre)	0.05	0.11	0.11
Ansar (3 lit/acre)	0.05	0.07	0.19
Ansar (1.5 lit/acre) + Paraquat (0.5 lit/acre)	0.05	0.14	0.10

Experiment No. 2. Arsenic residue in short-term Tocklai trial with Ansar 529 :

Table 14. Residue data from Tocklai trial in Nilgiris at estate I.

Treatment	P.P.M. arsenic in plucked shoots				
	1st Plucking	2nd Plucking	3rd Plucking	4th Plucking	5th Plucking
	(Pre-treatment)	(Post-treatment)			
Control	< 0.05	0.05	0.07	0.06	0.05
Ansar 5 lit/ha	< 0.05	< 0.05	< 0.05	0.07	< 0.05
Ansar 10 Lit/ha	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ansar 15 Lit/ha	< 0.05	< 0.05	0.07	0.07	0.05

Experiment No. 3. Arsenic residue data in short-term Tocklai trial with Ansar 529 :

Table 15. Weekly residue data from Tocklai trial in Nilgiris at estate II.

Plucking week	P.P.M. arsenic in plucked shoots			
	Control	Ansar 3 lit/ha	Ansar 6 lit/ha	Ansar 9 lit/ha
Pretreatment	< 0.05	< 0.05	< 0.05	< 0.05
1st week after treatment	< 0.05	0.06	0.05	0.09
2nd ,, ,, ,,	< 0.05	0.06	0.05	0.06
3rd ,, ,, ,,	< 0.05	< 0.05	< 0.05	< 0.05
4th ,, ,, ,,	< 0.05	< 0.05	< 0.05	< 0.05
5th ,, ,, ,,	< 0.05	< 0.05	< 0.05	0.05
6th ,, ,, ,,	< 0.05	< 0.05	0.09	< 0.05
7th ,, ,, ,,	< 0.05	< 0.05	< 0.05	0.10
8th ,, ,, ,,	0.06	< 0.05	< 0.05	< 0.05
9th ,, ,, ,,	< 0.05	0.06	< 0.05	0.09
10th ,, ,, ,,	< 0.05	< 0.05	< 0.05	< 0.05
11th ,, ,, ,,	< 0.05	< 0.05	< 0.05	0.08
12th ,, ,, ,,	0.05	< 0.05	< 0.05	< 0.05
13th ,, ,, ,,	0.05	0.05	< 0.05	< 0.05
14th ,, ,, ,,	< 0.05	< 0.05	< 0.05	< 0.05

Experiment No. 4. Arsenic residue in short-term Tocklai trial with Ansar 529 :

Table 16. Residue data from Tocklai trial at Borbhetta Field Station.

Plucking weeks	P.P.M. arsenic in plucked shoots				
	Control	Ansar 1.5 lit/ha	Ansar 3.0 lit/ha	Ansar 6.0 lit/ha	Ansar 9.0 lit/ha
Pre-treatment	0.10	0.13	0.10	0.10	0.13
1st week after treatment	0.08	0.08	0.09	0.08	0.13
2nd ,, ,, ,,	0.06	< 0.05	0.05	0.09	0.09
3rd ,, ,, ,,	0.06	N.A	< 0.05	0.05	0.06
4th ,, ,, ,,	0.05	0.05	0.09	0.05	0.09

(N.A. sample not available).

Experiment No. 5. Arsenic residue in soil and mature tea leaves with short-term application of Ansar 529 in pots:

Table 17. Resiude data from Tocklai pot trial with heavy doses of Ansar 529 (leaf and soil analyses six months after application of the test herbicide).

Treatment in pot	in mature tea	in sandy loam soil	
		Exchangeable	Total
Control	0.06	<0.05	0.65
50 kg Ansar/ha	0.09	0.36	1.40
100 kg Ansar/ha	0.09	0.50	2.50

III. Arsenic residue in mature tea leaves after continuous use of Ansar 529 at recommended rates for Weed Control for one or two years, under commercial conditions.

Table 18. Residue data from Harison and Crossfield Trials during 1972 and 1973.

Plucking Round	P.P.M. Arsenic in tea			
	First year (1972)		Second year (1973)	
	Treated	Check	Treated	Check
First	0.18	0.18	0.35	0.05
Second	0.10	0.10	0.19	0.08
Third	0.10	0.10	0.09	0.06
Fourth	0.10	0.10	0.23	0.07
Fifth	0.10	0.10	0.38	0.08
Sixth	0.10	0.10	0.21	0.20
Seventh	0.27	0.13	0.08	0.10
Average	0.14	0.12	0.22	0.09
	Difference Not significant		Treated plot has significantly higher residue.	

Table 19. Residue data from 1973 Harison and Crossfield Trial—One year only.

Plucking round	P.P.M. Arsenic in tea	
	Treated	Check
First	0.20	0.05
Second	0.44	0.14
Third	0.18	0.12
Fourth	0.10	0.20
Fifth	0.14	0.25
Average	0.21	0.15
	Difference Not significant	

IV. Consumable arsenic residue in tea brew.

*** Table 20. P.P.M. arsenic in brew made from commercial tea samples.**

Sample Description	Original tea (commercial samples)	Brew	Tea basis	Per cent Arsenic extracted
Mainland China				
Oolong (a)	0.18	0.002	0.12	67
,, (b)	0.14	0.002	0.08	57
Japan				
Green basket fired	0.55	0.003	0.15	21
,, ,, ,,	0.53	0.002	0.11	27
Formosa				
Oolong (a)	0.16	< 0.001	< 0.05	< 31
,, (b)	0.29	< 0.001	< 0.05	< 17
Srilanka				
Ratnapura Dist (BOPF)	0.26	0.003	0.15	58
Dolosbage Dist.(BOP)	0.20	< 0.001	< 0.05	< 25

* Analysed by WARF Institute INC., Madison,, Wisconsin

Studies on water table

Further observations on the yield and soil moisture content continued during the current year. Yields data are shown in Fig. 9.

It is interesting to note that the tea bushes grown with water table fixed at 90 cm from the surface yielded significantly higher crop than those having water table fixed at 135 cm throughout 1973, although no marked difference was observed last year between the bushes having water tables at 90 and 135 cm. The observed significant reduction in yield with 135 cm water table can be due to the ill-effects of short term drought occurring in the early part of 1973 resulting in cumulative depression in yield

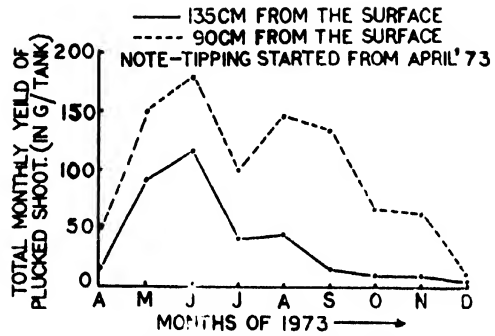


FIG.9: RELATIONSHIP BETWEEN YIELD AND DEPTHS OF GROUND WATER TASLE IN EXPERIMENTAL TANKS.

throughout 1973. However, this suggests that direct contribution of moisture from the water table by capillary rise (soil water content increases by 0.4 inches per acre for every 45 cm rise in ground water table in this experiment) during drought is as important as removal of excess moisture during rains. In the light of the above observation, Tocklai's recommendation of keeping the water table down at 90 cm from ground surface between two parallel field drains appear to be sound.

Drain spacing and permeability

Neighbouring estates in Jorhat circle were prospected in the monsoon period of the current year with an aim to study the ground water table and measure permeability under field situations. In each of the estate, on an average, six to eight sites were chosen representing different elevations. Permeability test was carried out in the field using Beer's auger-hole method.

The reconnaissance survey suggests that build-up of water table in the monsoon months is more likely due to the entry of foreign water (see page) rather than due to restricted permeability. Survey also suggests that subsoil drainage rather than run-off is of major importance in designing drains on these estates. For control of subsoil water (i.e., to bring the water tables down to 90 cm from the surface, mid-way between two parallel drains during monsoon), optimum horizontal spacings of field drains have been calculated on the basis of the permeability and textural data of these estate soils and advice given.

Run-off and erosion studies

In the artificially made run-off plots (varying in slopes) relationship between slope, rainfall intensity, and the total run-off was studied, and these results are shown in Fig. 10.

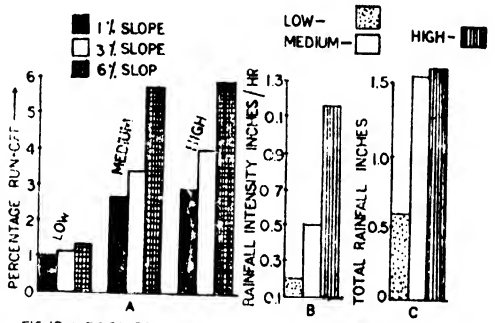


FIG 10 A,B&C: RELATIONSHIP BETWEEN RAINFALL INTENSITY SLOPE AND RUN-OFF

It is seen that percentage run-off increases with slope specially under the influence of "medium" and "high" intensity storms. However, run-off does not vary much between 1 and 3% slopes (see Fig. 14 A). Further, the negligible difference in run-off for any particular slope between the "medium" and "high" intensity storms may be caused by longer duration of the medium intensity storms than the high intensity ones since total rainfall between these two categories of storm does not differ (see Figs. 10 B and 10 C).

Rainfall characteristics

(i) **Rainfall intensity**

The first step to control excess storm water and consequently erosion is to determine the probable recurrence of storms of different intensities and durations in the tea growing areas of North East India. With this end in view long-term rainfall records (1960—1972) from automatic raingauges at Nagrakata (Dooars), Silcoorie (Cachar), Tocklai (South Bank), and Nagri Farm (Darjeeling) have been analysed.

Preliminary data are given in Table 21.

Table 21. No. of storms of various intensities and the p.c. of seasonal rainfall (monsoon) in various regions of N.E.India.

Month	Intensity	Region							
		Nagrakata		Silcoorie		Tocklai		Nagri Farm	
		No. of storm	p.c. of seasonal rain	No. of storm	p.c. of seasonal rain	No. of storm	p.c. of seasonal rain	No. of storm	p.c. of seasonal rain
June	1.0—1.5"/hr	108	24.82	19	35.9	14	11.3	46	19.46
	1.5—2.0"/hr	50	21.50	16	35.6	23	21.9	6	23.74
	>2.0"/hr	56	35.43	27	36.4	42	23.2	3	43.47
July	1.0—1.5"/hr	138	33.20	10	22.3	5	11.8	70	36.32
	1.5—2.0"/hr	75	39.55	13	32.4	23	25.1	7	29.00
	>2.0"/hr	39	29.31	13	17.2	49	27.8	2	22.97
August	1.0—1.5"/hr	88	20.46	10	23.6	5	16.4	59	22.64
	1.5—2.0"/hr	47	17.53	4	11.1	32	43.2	11	33.04
	>2.0"/hr	35	19.43	12	17.4	34	26.6	—	—
September	1.0—1.5"/hr	84	17.08	10	18.2	9	30.5	29	14.34
	1.5—2.0"/hr	41	16.74	7	20.9	10	9.8	4	14.22
	>2.0"/hr	25	11.44	21	29.0	37	22.4	3	33.56

It is seen that West Bengal areas, specially Dooars, received storms of higher intensities like 1.0-1.5 in/hr and 1.5—2.0 in/hrs more frequently than Assam throughout the monsoon period, although the percentages of the seasonal rainfall through such storms in Dooars have not been found to be very much different from those in Assam.

Further, Dooars receives double the number of storms of category 1.0—1.5 in/hr than the category 1.5—2.0 in/hr all throughout June to September; the minimum number of storms received during this period at Dooars is of the category 2.0 in/hr. Contrary to this, at Tocklai (South Bank) storms of very high intensity (above 2" /hr) has been found to be more frequent than those of either 1.5—2.0 in/hr or 1.0—1.5 in /hr.

At Cachar, the frequencies of all the three categories of rain storms appear to be almost at par during monsoon, with minor exceptions in August and September.

(ii) **Intensity-duration curves**

In order to obtain data on the total rainfall readily for durations other than one hour, a chart has been developed as shown in Fig. 11. The curves indicating the different durations on the chart have been obtained from an analysis of rainfall data for durations other than 1 hour (recorded at four differents meteorological stations over a long period).

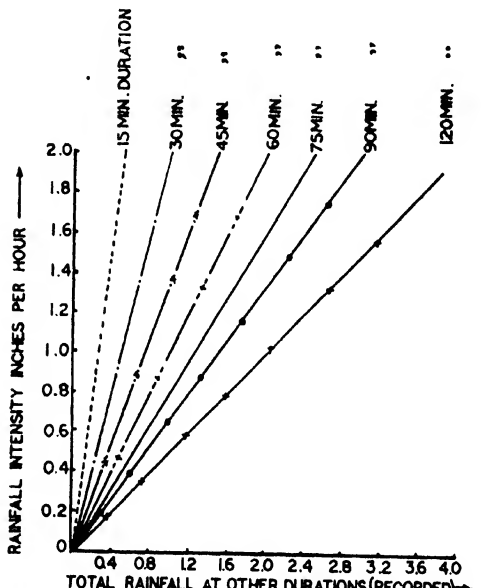


FIG. 11 RELATION OF ONE-HOUR RAINFALL INTENSITIES TO TOTAL RAINFALL AT OTHER DURATIONS (OR INTENSITIES AT OTHER DURATIONS)

(iii) **Monthly and seasonal distribution of rainfall**

Long-term rainfall records have been collected from the tea estates of different regions like South and North Banks of Assam Valley, Cachar, Dooars and Darjeeling, and these data were utilised for finding out both monthly and seasonal distribution of rainfall.

Although from June to September (monsoon) West Bengal estates record more rain than Assam, the trend appears to reverse in the dry period, specially during February to April. Winter and pre-monsoon rains have been found to be higher in Cachar than the other three regions.

Further, district-wise monthly and seasonal distribution of rainfall in the South Bank of Assam has been worked out. Irrespective of the month or seasons, rainfall, in general, increases as one travells from Nowgong to Upper Assam. However, there are minor exceptions like July and August rains in Nowgong being higher than Golaghat District, and Dibrugarh District B (Panitola, Dibrugarh and Moran) being slightly higher than Dibrugarh District A (Doom Dooma, Margherita, Tingrai and Nahorkatia) during May to September.

(iv) **Rainfall Map**

Isohcytal map (lines of equal Rainfall) of tea areas in Northern Bank of Brahmaputra has been prepared from long-term estate data.

Research and Advisory analysis

About 53,000 soil analysis have been carried out during the year. The break-up is as follows

(i) **Research :** For Soil's Department as well as for other Departments 12,600 estimations.

(ii) **Advisory :** For tea estates alone, 40,000 estimations.

Botany Department

General

Dr. D. N. Barua, Deputy Director cum Senior Botanist, retired on 31st July 1973 after 34 years of distinguished service to Tocklai and the Tea Industry of N.E. India.

Dr. H. P. Bezbaruah, Plant Breeder, proceeded to the United Kingdom in March 1974, for nine months for advance training cum research in Plant Breeding on a Royal Society Commonwealth Bursaries Scheme.

PLANT IMPROVEMENT

Production of clonal seeds

The seedlings from seven biclonal stocks (Ann. Rep. 1972-73, p. 45) were planted in a long-term trial for observation on their growth, yield and cup-characters. In general, all the stocks were observed to be fairly uniform in their growth and morphological characters.

Seeds of five of the biclonal stocks from the micro-baris were also distributed this year to Cachar and Dooars branches of the T.R.A. for trial in the respective areas. From the next season seeds of these biclonal stocks will be distributed to more areas in different agro-climatic regions for establishing large-size observation plots.

Two of the micro seed baris planted with China-hybrid varieties for production of quality seeds for Darjeeling areas are expected to yield sufficient seeds for trial from 1974.

Pollination programme

As sufficient number of seeds could not be obtained from last season's pollinations (Ann. Rep. 1972-73, p. 45), the series of crossing with TV 1 and TV9 as female parent were repeated again this year. Altogether 2055 crossings were done in 17 different crosses. A few interspecific crosses were also attempted with *C. caudata*, *C. kissi* and *C. japonica* using tea as the female parent. Initial observation indicates all the combinations are likely to be successful.

A few seedlings raised vegetatively from the *sinensis* x *japonica* hybrid were planted in the field for observation on their growth and vigour, as well as to obtain sufficient quantity of leaf for investigations on the chemical properties of the hybrid.

Production of Triploids

Out of the pollinations carried out between seven tetraploids and the quality diploid clones for production of high quality triploids (Ann. Rep. 1972-73, p. 45), viable seeds could be obtained only from the crosses with three tetraploid parents and the final fruit-set in the successful crosses varied from 13.8 to 46.9 per cent. Details are given in Table 1.

Table 1. Results of hand-pollination for production of triploids from crossings between diploid and tetraploid clones.

Crosses (Tetraploid × Diploid)			Per cent fruit-set
398/1	×	TV 1	0
		TV 3	0
		TV 7	0
398/2	×	TV 1	13.8
		TV 2	29.7
		TV 7	15.0
398/3	×	TV 1	0
		TV 3	0
		TV 7	0
398/4	×	TV 1	36.2
		TV 3	46.9
		TV 7	35.2
398/9	×	TV 1	45.4
		TV 3	22.7
		TV 7	28.0
398/11	×	TV 1	0
398/21	×	TV 1	0
		TV 3	0

In total 229 sinker seeds were obtained from the nine successful crosses. Seeds were sown in the nursery for observing percentage germination and growth and vigour of the seedlings.

Some more pollinations were done this year using only two of the tetraploid parents.

Release of vegetative clones

One more clone, TV 20, was selected for release during the year.

TV 20 is a standard clone with excellent growth habit, possessing high yield potential. The clone is of light, broad-leaf Assam type and is suitable for both C.T.C. and Orthodox manufacture. The detailed characteristics of the clone are given below:

Category	..	Standard clone
Growth	..	Fast-growing, vigorous
Frame	..	Spreading
Leaf-type	..	Light-leaf, large
Shoot size	..	Large
Pubescence	..	Low
Rooting	..	Good
Yield	..	High
Quality	..	Good, with a touch of raspberry flavour

Order of preference to manufacture :
(a) C.T.C.
(b) Orthodox.

The drought resistant properties of the clone are under study. However, our initial observation from Dooars and Cachar appears to be quite favourable.

Mother bush selection

About 13 bushes were selected from an old section of Dulia Assam jat at Borbhetta during the year. They were put into rooting trial in autumn 1973.

Selection work was also carried out in an old section of hybrid type of tea in a neighbouring estate. Out of the initial selection of 45 bushes, twenty bushes were found to be promising on the basis of yield and quality tasting carried out during the season. These will be put into rooting trial next season.

Long-term trial of clones

Out of the long-term trial of the yield series of clones completed during the year, one yield clone was finally selected for release to the Industry. The release of the clone will be announced as soon as multiplication plots are established.

From the long-term trial started in spring 1970, three clones, one quality clone and two standard clones, were tentatively selected for release in the near future.

One of the long-term trials planted in spring 1971 in which 46 clones are under trial, produced sufficient quantities of leaf during the season for manufacture in 1 kg rollers. From the initial tasting and yield records, four clones appear to be promising. The trial will be continued for a few more years before final selection.

Although sufficient leaf for 1 kg manufacture from other two long-term trials planted in autumn 1971 was available towards the back-end, only 60 gm samples could be manufactured during the entire season. Tasting results and crop records indicate quite a few clones to be promising.

From the rooting trial of 44 mother bushes in 1972 (Ann. Rep. 1972-73, p. 46), 31 clones were selected on the basis of rooting ability and seedling vigour and were planted in a long-term trial in autumn 1973.

Preservation of genetic resources of tea

Nine estate selected clones of different types were added to the list of reserve stocks during the year. The clones may be used in future breeding schemes after evaluation of their characteristic properties.

Selection of clones in Tea Estates

One estate was assisted in clonal selection scheme during the year.

Induction of Mutation

The suspected mutant plant reported in the Annual Scientific Report 1972-73, p. 46, was propagated vegetatively for planting trial plots to evaluate its cup characters and yield potential. As sufficient number of cuttings could not be obtained from the first pruning, more cuttings will be taken this year to plant out a long-term trial next season.

Observations on the seedlings raised from seeds and clonal cuttings irradiated with different dosage of X—rays (Ann. Rep. 1972-73, pp. 46-47), showed

no signs of any visible mutation. The plants are kept in the nursery for further observation.

A further lot of cuttings of clone TV 10 and TV 18 were irradiated with different dosage of X-rays at Jute Agricultural Research Institute, Barrackpore. The plants are under observation in the nursery.

PLANT PHYSIOLOGY

Shade Pattern in North-East Indian tea plantation

The 'shade-tree' tradition in the tea plantations which started from the early years of growth of the tea industry in Assam, is possibly one of the most intensely investigated problems and contentious issues in tea research. The practice established in North-East India was also followed in almost every other tea growing area in the tropics, many of which had very different climatic and soil conditions. Thus, the necessity of shade had rarely been questioned. However, during the last two decades removal of shade trees coupled with increased doses of inorganic fertilisers generally resulted in increased yield in Sri Lanka and Africa, while in North-East India yield decreased in most cases.

These anomalous reports necessitated a detailed investigation on the whole problem of shade in tea plantations. Therefore, a few experiments were carried out during last few years to investigate the nature of aerial environment under shade and its effect on the growth and development of the tea bush.

The study included the pattern of shade under different shade tree species, the light received by different levels of foliage in tea plantations and to relate the physiology of the tea plant in the field to those environmental factors influenced by sunlight and modified by shade tree canopy. The environment of light, referred here as light climate in the open and under shade trees and its spectral composition for the spectral region 380—1400 nm under different environmental conditions were investigated. Leaf-temperature of self-shaded and fully exposed leaves of horizontal, erect and semi-erect varieties in different light intensities, as well as effect of air movement and transpiration on leaf temperature and stomatal movement were also studied in detail.

The mass of data collected from different experiments are under processing, the details of which will be published elsewhere. A brief report of the findings on shade pattern is presented below:

(a) The light climate in the open

In order to compare the extent of change in the aerial environment under the shade, the light climate in the open under Tocklai conditions (Latitude 26°17′ N, Longitude 94°12′ E, Elevation 86.6 m above mean sea leavel) was studied for a few years as a preliminary step.

The monthly average day-length at this latitude varies from 10 h. 28 min. to 13 h. 48 min. Considering the year into two halves, summer (May to October) and winter (November to April), the total irradiance measured appears to be much more nearly equal than the theoretical calculations would suggest. The calculated differences of summer and winter half year totals of direct radiation are about 38,000 and 43,000 cal/cm^{-2} for transmission coefficients of a = 0.6 and a=0.7 respectively, whereas the actual difference is about 8000 cal/cm^{-2}. This may be explained from the fact that inspite of longer day length during the monsoon, the radiation regime in terms of calories per day remains fairly constant because of cloud cover during this period of maximum potential radiation. The annual mean percentage of hours of bright sunshine to total daylight hours at Tocklai is only about 47.7%, the variation from the mean being 36% for the May—October period and 61% for the November—April period.

(b) The light climate under shade trees

The light climate on the bush surface was studied from an area of 30 × 30 m (400 bushes planted at 1.5 m square) of mature tea with an uniform stand of about twelve year old shade of *Albizzia odoratissima* planted at 7.5 × 7.5 m apart. For three years the light intensity on the surface of each bush was

measured at all hours of daylight on 88 days spread throughout the year.

These studies indicate that the light intensity on the surface of the tea bushes under shade trees varies not only during different times of the day but the light pattern also varies during different times of the season, which may again be greatly modified by the nature of the shade tree canopies. On a typical clear day in June, when the shade trees are fully foliated and the sun is almost directly over-head at noon, the mean light intensity over the whole area is about 60% of full sunlight but the amount received by individual bushes varied from 35 to 94%. Two hours later (14.00 hrs) the total light in the area was about 57%, which reduced to about 43% by 15.00 hours, the variation between the bushes receiving light being from 21 to 62%.

By contrast the shade trees in the section at 14.00 hours on a clear day in November produced a fairly uniform shade and the total mean light intensity was found to be only 26% of the full light in the open, with a variation of 18—35% between the bushes.

These variations in the shade pattern over the bush surface are easily explainable if the distribution of sunflecks reaching the bush surface through the large gaps between the tree canopies are taken into consideration. Observations on a clear day in June from 08.15 to 15.15 hours showed that between 59 and 83% of the total area is occupied by sunflecks at different periods of time. If distribution of the bushes receiving between 90 and 100% sunfleck is calculated, it may be observed that some 50% of the bushes received almost full sunlight between 10.15 and 14.30 hours. It is, thus, apparent that most of the tea bush surface received either too much shade during the hours when the sun's irradiance was minimal or too little when radiation was high.

It can be concluded from these observations that most of the light reaching a tea bush is in the form of unmodified sunlight, either from large canopy gaps between trees or from sunflecks.

Screening of shade tree species

The selection of suitable shade trees for use in tea plantations remains a major problem in North-East India. The procedure followed in the past for trial of shade tree species was time consuming and it is often many years before reliable results are obtainable. However, by studying the canopy characteristics and light transmission, it is likely to be possible to eliminate many species at an early stage and the area survey method is ideally suited for this purpose.

In a five year old long-term trial of ten potentially useful shade trees, light intensities directly beneath the canopies were measured at noon on clear days between May and October. Canopy spread was taken into account along with the height, trunk diameter and period of foliation. Results are shown in table below :

Species	Effective canopy width in metre	Mean light intensities directly beneath the canopies	Period of foliation
1. *Derris robusta*	7.32	46%	Dec.-April
2. *Cassia siamea*	7.62	20%	Evergreen
3. *Phyllanthus emblica*	11.58	42%	Dec.-March
4. *Chukrassia tabularis*	7.32	33%	Jan.-Feb.
5. *Albizzia odoratissima*	8.53	44%	Dec.-Mar.
6. *A. chinensis*	10.97	55%	Feb.-May
7. *A. zygia*	13.41	56%	Evergreen
8. *A. moluccana*	12.30	27%	Jan.-Feb.
9. *A. maranguensis*	15.24	25%	Evergreen
10. *A. grandibracteata*	14.63	43%	Evergreen

From these observations it is possible to forecast the shade pattern to be expected from a particular species of shade tree. For example, *D. robusta* and *A. grandibracteata* give similar values of light intensity, but as there is a four-fold difference in the area covered by the two species of the same age, the spacing, requirements are obviously different. Similarly, between *A. chinensis* and *A. moluccana* of same spread, the low light intensities under the latter species indicate its upright habit producing dense canopies

The shade trees were surveyed again after 10 years and in every case the mean light values were found to decrease, in some cases quite considerably. These observations clearly suggest that by use of the survey method it is possible to exclude many species before the field trial stage and only those trees which

allow an adequate proportion of light in the form of sunflecks to penetrate the canopy may be selected for the time consuming and expensive trials.

Root studies

Stock-scion relationship on root-growth

Earlier investigations on stock-scion interaction on yield and quality (Ann. Rep. 1970-71, p. 44) showed that the stock greatly influences the vigour and leaf yielding capacity of the scion. In order to investigate if the scion also influences the growth of the root system of the stock, a series of reciprocal grafts were done using low, medium and high vigour clones. Observations showed that scion did not influence total weight, depth or spread of the root-system of the stock varieties.

Dormancy of tea

In continuation of the earlier experiments on the possibilities of breaking dormancy in tea with growth regulating substances (Ann. Rep. 1970-71, p. 51; 1971-72, p. 49), a further series of investigations were carried out on the effect of different growth regulating substances like Gibberellic acid (GA_3), Indole-3-acetic acid (IAA), Kinetin (K), Abscissic acid (ABA), Potassium nitrate (KNO_3) and Glucose etc. on the bud-break and subsequent growth of the tea bushes. One year old seedlings of TV 1, TV 18 and a China-hybrid clone were sprayed with different concentrations of the chemicals four times at monthly interval from December to March. GA_3 alone and in combination with IAA showed earlier bud-break in all the clones during winter. Plants treated with the combination of GA_3 and IAA also showed rapid flush of growth with greater internode length. However, banjhiness between two successive growth phases could not be prevented by any of these treatments, but the length of banjhi period could be reduced considerably. The clones treated with GA_3 and GA_3 + IAA also produced one extra flush of growth during the winter.

Further work on the line is in progress.

Entomology Department

TEA MITES

Developmental response of mites : Scarlet mite, *Brevipalpus phoenicis* (Geijskes) and Red spider, (*Oligonychus coffeae* (Nietner) were reared on Tocklai clones TV1, TV2, TV3, TV4 and TV5 to find out if their developmental rates would vary with clones.

The fecundity of scarlet mite was highest on TV4 (27 eggs) and least on TV1 (5 eggs) the rest of the clones being intermediate in position. Notwithstanding this difference, the duration of the life cycle of the mite on the five clones was nearly same at any particular time of the year. As in scarlet mite, the developmental rate of red spider on the five clones did not vary significantly.

Exposure to various humidities (50, 70, 90 and 100% RH all at 30°C) had little effect on the duration of the life cycle of red spider, which at all humidities was completed in approximately 9 days. Possibly temperature is of crucial importance in the build up of mite population.

Mite incidence in relation to differential manuring : Seasonal incidence of red spider on mature tea (age 12 years) manured differentially with 0, 50, 100 and 150 kg N/ha was assessed. The preliminary data did not indicate any clear cut difference in the populations of red spider on bushes treated with manures at different rates.

Clonal susceptibility to red spider : Incidence of red spider was assessed during August to December to find out the susceptibilities of some Tocklai clones during this period of natural decline of the mite population. The clones studied were TV13 to TV19, all ten years old. Overall mite population was low as was expected, but mite populations on TV15, TV16 and TV18 were significantly lower than those on the rest of the clones.

COCKCHAFER

Biology of Cockchafer : *Sophrops plagiatula* (Brenske) damages young clonal tea in the North Bank. The early instars feeding on organic mulch developed quicker than those feeding on tea cuttings. The late instars prefer as food clonal cuttings to Crotalaria stem when no organic mulch was supplied.

Feeding experiments in the laboratory indicate all the larval instars do not produce the same magnitude of damage. The early instars damage the bark only in patches and these plants may even survive, if the debarking is not too severe. Late instars eat away the ring of bark in the collar region thus hastening the death of the plant. A full grown larva can debark an area of 280–380 sq. mm in 24 hours. It is possible that the collar region of freshly planted cuttings can be completely debarked in 24 hours.

NEMATODES

Pathogenicity of root knot : Second instar larvae of *Meloidogyne incognita* Chitwood were inoculated into nematode free soils at different density levels and tea seedlings were grown on them. The seedlings were examined after 75 days to find out the level of nematode damage at various density levels. Nematodes multiply differentially at different density levels. A set of results presented in Fig. 1 shows a near linearity between gall formation and nemadote density level. Interestingly enough galls were produced even at a low density level of 10 nematodes in 10 grams of soil.

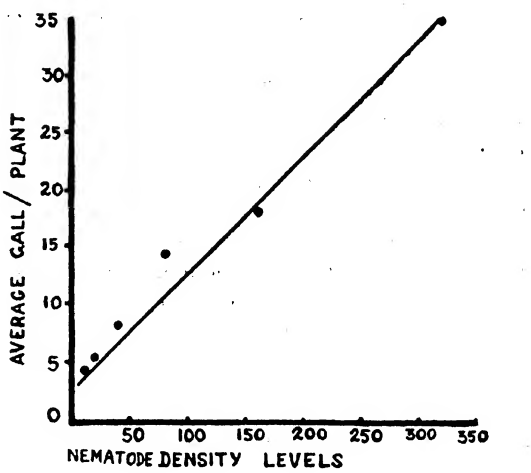


Fig. 1.

Clonal resistence : Of the four Tocklai clones TV13 and TV15 were found to be slightly more susceptible to the root knot, *Meloidogyne incognita*, than TV1 and TV18, the average galling on the former clones were 1.0 and 2.0 galls per plant respectively. The second instar nematodes within these galls failed to develop into adults.

Organic dressings and nematode pathogenicity : Tea seedlings were grown on nematode infested soils dressed with oil cakes of mustard, sesame and groundnut each at the rate of 0.5, 1.0 and 2.0 g in 100 grams of soil. Pathogenic effects following these treatments were assessed after 60 days from the counts of galls on the roots of the seedlings. Results in Fig. 2 show that organic dressings under all treatments significantly decreased gall formation and the effects were more pronounced at comparatively high rates of application.

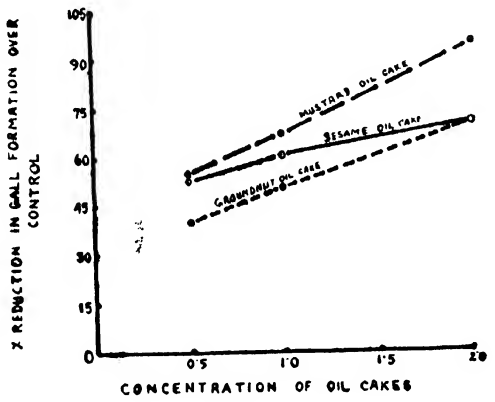


Fig. 2.

Effect of oil cake extracts on nematode mortality : Second instar larvae of *M. incognita* were released in glass cubicles having water soluble extracts of oil cakes of mustard, sesame and groundnut at 0.001%, 0.01% and 0.2% concentrations. After 72 hours at 0.2% concentration mortality was highest and least at 0.001%. The practical utility of these observations is being looked into.

Alternate hosts of root knot : The following species of weeds were found to be alternate hosts of root knot nematode (*Meloidogyne incognita*). The degree of susceptibility of these weeds is also indicated.

Bad host	Medium host	Good host
Lemmurus sibiricus (?)	*Erechthites valerianaefolia* D. C.	*Sesbania aculeata* Poir
Gnaphalium indicum L.	*Alternanthera sessilia* R. Br.	
Chenopodium album L.	*Solanum khasianum* Clerk.	
Borreria hispida K. Schum	*Solanum nigrum* L.	
Digitaria pruriens Buese	*Mimosa pudica* L.	
Eleusine indica Gaertn.		

Some of these weeds at the time of planting act as foci of nematode infestation for young tea.

NATURAL CONTROL

Predator and parasites of tea pests : A survey was conducted on the available predators and parasites of 32 species of pests. A list has been published in June 1973 issue of *Two and A Bud*. Predators were not always present in sufficient numbers at any one time to be of consequence in the regulation of pest populations.

BIO-ASSAY STUDIES

Bioeffectiveness of "X-factor" and Lindane: An inter institutional project of C.S.I.R. Biological Research Council envisages development of chlorinated hydrocarbons which unlike Gamma isomer are much less toxic to human being. Various isomers developed by CFTRI are being assessed in their potentiality as insecticides. The third instar caterpillars of *Andraca bipunctata* Walker were controlled at 0.025% concentration of the insecticide, code named X-factor and Lindane applied topically. But the full grown caterpillars were knocked down only at 0.05% concentration of X-factor though similar results were obtained with Lindane even at 0.025% concentration.

Against mixed population of different instars of looper caterpillars, *Biston suppressaria* Guen, X-factor at 0.05% concentration resulted in 98% mortality in 48 hours. This insecticide was slower in action on loopers than on bunch caterpillars.

SPRAY DEPOSIT STUDIES

Distribution of spray droplets: The effect of rainfall on the distribution of spray droplets within the bushes was studied. Top hamper of the bushes was sprayed with Tedion (1 : 500). Following a light shower, most of the pesticide droplets got removed from the upper part and redeposited at lower levels. The redeposited chemical caused a mite mortality in the region of 50% as against 98% under dry conditions. With heavy rainfall the redistribution of the pesticide within the bushes was least and most of it got washed off. Pesticide droplets collected at the bottom of the bushes indicated that in some cases the dilution went upto about 1 : 2000. With a sticker 29 ppm of the acaricide was retained following exposure to $\frac{1}{2}$ inch rainfall, and 5 ppm in the absence of a sticker.

ACARICIDES

Red spider control with low concentration of acaricides : Several new organo-phosphate acaricides were tried at 0.75 litre and 1.00 litre per hectare for controlling existing infestations of red spider mites. A set of result is set out in table 1. Although some variation exists in the initial performances of the acaricides, they were nearly equitoxic after 4 weeks. There was no siginificant difference in the performance of these acaricides at 0.75 and 1.00 litre/hectare. Efficient spraying of any one of these acaricides at 0.75 litre/ha should prove effective.

Table 1. Low concentrate applications of some new acaricides in controlling red spider.

Treatments	Observations after —					
	1 week		2 weeks		4 weeks	
	Mean Red spider population per 50 leaves	% reduction over control	Mean Red spider population per 50 leaves	% reduction over control	Mean Red spider population per 50 leaves	% reduction over control
Acarthane @ 1.00 l/ha	0.33	99.7	1.00	98.0	0.00	100.0
Acarthane @ 0.75 l/ha	27.67	81.5	4.33	93.0	0.33	99.0
Mico-15 @ 1.00 l/ha	0.33	99.7	2.00	97.0	0.00	100.0
Mico-15 @ 0.75 l/ha	44.33	70.4	3.33	94.0	0.00	100.0
Omite @ 1.00 l/ha	1.33	99.1	2.00	97.0	0.00	100.0
Omite @ 0.75 l/ha	5.67	90.6	6.00	90.0	0.67	98.6
Cidial @ 1.00 l/ha	42.33	71.1	1.67	97.0	1.33	97.1
Cidial @ 0.75 l/ha	87.00	42.0	7.33	88.0	0.67	98.6
Control (untreated)	150.00	—	60.33	—	46.00	—

Residual toxicities of acaricides against scarlet mite and pink mite : Scarlet mite infested bushes were treated with Mico 15, Ambithion 500 E, Bidrin 24 EC, Cidial 50 EC and Nuvacron 40 EC, each @ 1.25 litre/hectare. Mite counts were made 72 hours and four weeks after the chemical treatment to find if the residual actions of these acaricides were still functional. Table 2 shows that after four weeks of treatment performances of Bidrin and Ambithion were not significantly better than that of the control series, but those of Mico-15, Cidial 50 E.C. and Nuvacron 40 E.C. were. The last three acaricides were equitoxic against scarlet mite. After 72 hours, however, Bidrin and Ambithion were also very effective.

Table 2. Residual toxicities of some acaricides on Scarlet mite under field conditions.

Treatments	After 72 hours		After 4 weeks	
	Mean population per 25 leaves	% reduction over control	Mean population per 25 leaves	% reduction over control
Mico -15 @ 1.25 l/ha	1.00	97.44	25.33	73.33
Ambition @ 1.25 l/ha	3.67	90.59	54.33	42.81
Bidrin @ 1.25 l/ha	3.00	92.31	58.00	38.94
Cidial @ 1.25 l/ha	1.00	97.44	27.00	71.57
Nuvacron @ 1.25 l/ha	1.33	96.59	27.33	71.23
Control (untreated)	39.00	—	95.00	—

Residual actions of Dicofol, Omite 57 E, Cidial 50 E.C. and Phosvel 34 E.C. @ 1.25 litre/ha after four weeks were effective against pink mite. Mico-15, Nuvacron 40 E.C. and Tetradifon caused immediate mortality but had no significant effect after four weeks (Table 3).

Table 3. Residual toxicities of some acaricides on pink mite under field conditions.

Treatments	After 1 week		After 4 weeks	
	Mean population per 25 leaves	% reduction over control	Mean population per 25 leaves	% reduction over control
Omite @ 1.25 l/ha	6.33	98.64	7.33	87.21
Cidial @ 1.25 l/ha	0.00	100.00	12.00	79.96
Mico—15 @ 1.25 l/ha	0.33	99.75	26.33	54.07
Nuvacron @ 1.25 l/ha	2.66	99.51	30.00	47.14
Phosvel @ 1.25 l/ha	16.33	96.99	15.33	73.25
Dicofol @ 1.25 l/ha	18.33	96.62	2.66	95.36
Tetradifon @ 1.25 l/ha	1.66	99.69	32.33	43.60
Control (untreated)	543.66	—	57.33	—

INSECTICIDES

Red Borer : The red borer, *Zeuzera coffeae* Nietner is an important pest of young tea. It caused considerable damage to young tea, in the North Bank. Following the removal of affected shoots, the infested bushes were sprayed during March 1973 with Nuvacron 40 E.C., Ambithion 500 E, Dursban M and Phosvel 34 E.C. each at 1.25 and 2.00 litres to a hectare. Assessment made in the following season indicated that only Nuvacron @ 2.00 litres/hectare protected 80% of the plants from fresh infestation. Rest of the insecticides at both the dilutions gave between them 36 to 47% protection from fresh infestation.

Red slug caterpillar : Caterpillars of *Eterusia magnifica* Butl. caused severe damage to mature tea in the North Bank and the Dooars. Spraying was done in the afternoon when the caterpillars were

most active on the maintenance foliage of the bushes. In addition to all the insecticides mentioned under "Red Borer", Starsulfan 35 E.C. and Gardona 24 E.C., each at 1.25 litre/hectare caused about 98% mortality to caterpillar populations. These insecticides were therefore equitoxic against this pest.

Bark eating borer : The bark eating borer, *Inderbela theivora* Hamps is difficult to control by ordinary spraying of insecticides unless a suitable sticker is added. Nuvacron 40 E.C., Phosvel 34 E.C. and Asafan 35 E.C. @ 1.25 litre/ha with 800 cc of the sticker, Pervenol, were sprayed following removal of web runs, characteristic of the borer damage. A parallel series was run in which insecticidal solutions without the sticker were injected. Observations were taken four weeks after the treatments to find out the effectiveness of the chemicals which was assessed from the absence or presence of the web runs on the stems. In all insecticidal treatments incorporating the sticker, control was better than those without sticker. The effectiveness of the insecticidal solutions with sticker lasted over 12 weeks.

Termite : In controlling termites (*Microcerotermes* spp), Phosvel 34 E.C., Birlane 24 E.C. and Dursban M were applied at 1: 500 parts of water by volume to infested bushes following removal of earthen runs, and without removing them. Better control was always obtained when earthen runs were removed. Performance of Phosvel 34 E.C. and Dursban M was better than that of Birlane 24 E.C.; because of their low residual toxicities none could keep the termites under effective control for more than six months.

Table 4. Effect of some insecticides on the subsequent build up of termites as evident from construction of earthen runs.

Treatments		Average length of earthen runs per bush in cm (50-bushes)	Average degree of infestation per bush (50 bushes)
Insecticides	Earthruns		
Phosvel @ 10 l/ha	Removed	5.8	0.50
	Not removed	8.6	0.56
Birlane @ 10 l/ha	Removed	8.4	0.61
	Not removed	10.3	0.87
Dursban @ 10 l/ha	Removed	5.4	0.40
	Not removed	6.4	0.50
Control	Removed	13.0	1.00
	Not removed	15.3	1.20

NEMATOCIDES

Control of root knots : Soil application of Temik 10 G @ 50 kg/hectare gave 40% control of *Meloidogyne incognita* after four weeks. However, there was slight rise in the population in the subsequent months, although even after ten months the population did not reach the pre-treatment level.

DBCP at 0.05 cc and 0.1 cc to 1000 grams of pot soil failed to control root knot population. But at 0.2 cc DBCP gave nearly 90% control of the existing population of root knots.

PESTICIDE RESIDUE

Tolerance level on made tea : On the basis of our work and recommended rate of application Environmental Protection Agency (EPA) of the United States has granted a tolerance level of 24 ppm to Thiodan 35 E.C. on made tea. This reflects less than 5 ppm residue in brewed tea. Our work also forms the basis for a tolerance level of 20 ppm of Trithion on made tea.

Green leaf and dry samples of tea were also prepared for analysis of residues of Phosvel. They have been despatched to Velsicol's Laboratory at Chicago.

MISCELLANEOUS

Inter-Institutional work : The Department of Entomology continued to get assistance on taxonomical problems from the Commonwealth Institute

of Entomology, London. The department collaborated with Central Food Technological Research Institute in evaluating new insecticides developed by them, and with the Tropical Products Institute, London, for residue work.

Visiting worker and Training : Dr. D.M. Benjamin, Professor of Entomology, University of Wisconsin at Madison (USA) worked in the department as a guest scientist. Mr. N. Sengupta was at East Malling Research Station, England, for three months on specialized training in biological control. Mr. D. Saharia and Mr. M. Sharifullah of the Department of Entomology, Assam Agricultural University, continued their doctoral research in the department.

Advisory work : Pest infested materials sent by Advisory Departments and member estates were examined and remedial measures suggested. In addition, soil samples sent from estates were analysed for eelworm populations. Bioassays were also done for samples of pesticides received from member estates.

Certificates and Agreements : 13 Certificates were issued to plant protection chemicals. Of these 9 certificates were revalidated after bioassay studies. Agreements for formal tests were made for 15 pesticides.

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Mycology Department

Red rust vs. soil compaction

Red rust caused by *Cephaleuros parasiticus* on tea is known to be more severe on clayey and heavy soils. To study the relation between the soil compaction and red rust incidence, an experiment was initiated in 1971 to assess the effect of soil compaction on growth of the plants and subsequent red rust infection. For this, 2 clones viz. TV1, known for its susceptibility to red rust and TV9, a comparatively resistant one were used.

Two series of 10 boxes each of 30 cm × 30 cm × 30 cm were used. Series A was filled with 20 kg soil while the other series B received 30 kg 4 cuttings per box were planted in December 1971 and the boxes were kept under overhead shade and watered as and when necessary.

The following observations were made.

I. The soil in Series A sank gradually by about 3 cm and did not develop much of moss or blue green algal mats while in the other excessive moss and blue green algal crust developed.

II. The plants in Series B became stunted in appearance and carried fewer and smaller leaves.

III. The number of surviving plants declined further with time in Series B and there was no survivor left by December '73 in the Series. Results are presented in Table 1.

Table 1. Effect of soil compaction on growth and survival of tea plants.

Soil per box	Clone	No. of living plants out of 20			Av. height per plant in cm	
		May '72	May '73	Dec. '73	May '72	May '73
A 20 kg	TV1	8	6	6	12	71
B 30 kg	TV1	7	3	0	8.7	18
A 20 kg	TV9	16	16	16	16.4	81
B 30 kg	TV9	15	9	0	8.0	28.3

The comparison for red rust infection in loose and compact soils, which was expected to be made, could not be undertaken as all the plants in the series with more compact soil did not survive.

Red rust The importance of applying 4 rounds of copper formulation during the sporulating period (end April to mid July) of the alga has been worked out (Ann. Rep. 1972-73). This year possibility of spraying a lower quantity of copper (Blitox) with and without Idet, a spreading and wetting agent were investigated on a red rust infested TV1 area with the following treatments:

Treatments

1. Blitox at 1 in 400 parts of water (usual dilution which works upto 2.5 kg/ha).
2. ,, 1 in 500 parts of water – 2 kg/ha
3. ,, 1 in 1000 ,, ,, – 1 kg/ha
4. ,, 1 in 500 ,, ,, ,, with idet.
5. ,, 1 in 1000 ,, ,, ,, ,,
6. Unsprayed control.

Four applications, the first two at fortnightly and the subsequent ones at monthly intervals were done using hand operated Bakpak sprayers. The degree of incidence of the disease was recorded in the scale of 0-4 depending on whether the disease development was absent, slight, medium, severe or very severe, and the results are tabulated below (Table 2).

Table 2. Incidence of red rust on a score of 0 4 as influenced by different dilution of an effective formulation.

Treatment	Mean degree of incidence per bush
1. Blitox at 2.5 kg/ha	0.81
2. Blitox at 2 kg/ha	0.89
3. Blitox at 1 kg/ha	1.60
4. Blitox at 2 kg/ha Idet 0.7 kg/ha	1.03
5. Blitox at 1 kg/ha Idet 0.7 kg/ha	1.64
6. Control no spray	2.56
C.D at P 0·05	0.47
CV %	24.8
No. of bushes per treatment	160

It is evident from the above that the degree of control achieved declined significantly when the

formulation was used at 1 in 1000 parts. No beneficial effect of addition of idet was noticeable.

Red rust : Screening of chemicals—Two trials were laid out for testing the efficacy of some new products. In one trial, hand operated knapsack sprayers were used while in the other, power sprayers of Fontan type were used. The spraying was done on 4 occasions during the sporulating period of the alga (from May to July)—the first 2 rounds at fortnightly interval and the subsequent ones at monthly interval. The formulations used were Dikar (Rohm & Haas, Indofil Chemicals), Difolatan (Chevron chemicals—Tata Fison), Dithane M45 (Rohm & Haas and Indofil), Dithane C90 (Rohm & Haas—Indofil), Hoe 6052 Sicarol 50WP (Hoechst) Idet (Selser Marketing), Blitox (Tata Fison), Starcop (Shaw Wallace).

In the trial where power sprayer was used all the chemicals were applied at the rate of 2.5 kg/ha with the exception of Hoe 6052 Sicarol 50WP which was used at 0.300 kg/ha, Idet, a spreader, was used at 625 ml/ha with the two copper formulations (Blitox & Starcop). The results are shown in table 3.

Table 3. Degree of incidence of Red rust in 0-4 scale as influenced by different chemicals when applied with a power sprayer.

Treatments	Rate of application kg/ha	Degree of incidence per bush
Control	-	2.77
Hoe 6052 Sicarol 50WP	0.3	2.93
Dithane M 45	2.5	2.74
Dithane C 90	2.5	2.51
Dikar	2.5	2.14
Difolatan	2.5	1.00
Starcop	2.5	0.99
Blitox + Idet	2.5	0.71
Starcop + Idet	2.5	0.67
Blitox	2.5	0.37
C. D. at P = 0.05		0.49
CV %		20
No. of bushes per treatment		144

In the other trial using hand sprayer Hoe 6052 Sicarol 50WP was applied at 0.03% suspension and the other as 0.25% suspension. The degree of infection in the area was lower in comparison with other area. The results are given in Table 4.

Table 4. Degree of incidence of Red rust in 0-4 scale as influenced by different chemicals applied with Hand Sprayers.

Treatments	Per cent chemicals used	Degree of disease incidence per bush
Control	- -	1.90
Hoe 6052 Sicarol 50WP	0.03 %	1.43
Dithane M 45	0.25%	1.31
Dikar	-do	1.20
Dithane C 90	-do-	1.09
Difolatan	-do-	0 84
Starcop + Idet	-do-	0.61
Starcop	-do-	0.48
Blitox	-do-	0.45
Blitox + Idet	-do-	0.25
CD at P = 0.05		0.44
CV %		31.4
No. of bushes per treatment		80

It appears from the above two tables (Nos. 3 and 4) that in addition to the copper fungicides (Blitox & Starcop) only Difolatan gave appreciable reduction of the disease.

Thorny stem blight

A new fungicide (JF 4065) pp 395 has been received for trial against Thorny stem blight. A trial was laid using the product at 250, 500 and 1000 ppm. as a post pruning measure. Another treatment with Indopaste was included besides one untreated control. The experiment will be continued.

Systemic fungicide and Thorny stem blight

Observation on the development of the disease in the plots receiving a systemic fungicide is continued to see if the application has any mitigating effect on the disease incidence.

Black rot : Screening of fungicides—The following formulations were tested for their efficacy in controlling Black rot during the season : Dikar, Difolatan, Dithane M45, Dithane C90, Hoe 6052 Sicarol 50WP, Idet, Blitox and Starcop.

The mean degree of incidence per bush is tabulated below (Table 5).

Table 5. Effect of chemical spray on the incidence of Black rot on a score of 0-4 (mean incidence per bush).

Treatments	Dilution	Disease incidence
1. Control		1.26
2. Hoe 6052 Sicarol 50WP	1 in 3300	0.87
3. Dikar	1 in 400	0.79
4. Dithane C 90	1 in 400	0.75
5. Dithane M 45	1 in 400	0.72
6. Difolatan	1 in 400	0.46
7. Starcop + Idet	1 in 400	0.35
8. Starcop	1 in 400	0.32
9. Blitox + Idet	1 in 400	0.16
10. Blitox	1 in 400	0.12
CD at P = 0.05		0.25
CV %		35.1
No. of bushes per treatment		140

It is evident that the copper fungicides (Blitox & Starcop) gave the best control of the disease followed by Difolatan. Others were significantly inferior to them even though they reduced the disease significantly over control.

Chemical control of Black rot

The residual effect of giving 2 rounds of copper fungicide at the time of development of the disease from its resting stage (sclerotia) with the onset of rains is being studied in an experiment initiated in the North Bank in 1968.

The plots were sprayed with a standard copper oxychloride (Blitox) in 2 rounds at fortnightly interval in May—June during the first 2 seasons (1968 and 1969) only, no further copper spraying has been done there since then. The degree of incidence of Black rot per bush and yield return per plot of 40 bushes (6 replicates) for the season 1973 are given in table 6.

Table 6. Effect of chemical control on the incidence of Black rot (on a score of 0-4) and yield of green leaf in 1973.

Treatment Blitox rate with type of sprayer.	Incidence per bush	Disease incidence as % of control	Av. yield of green leaf in kg per plot of 40 bushes	% increase over control
1) at 4.5 kg/ha with knapsack	0.38	61.3	26.4	11.4
2) at 2.5 kg/ha with Fontan	0.56	90.3	26.9	13.5
3) at 4.5 kg/ha with Fontan	0.34	54.8	26.8	13.1
4) Unsprayed control	0.62	100	23.7	
C.D at P = 0·05	0.20		1.7	
CV %	34.3		5.3	
No. of bushes per treatment			240	

Residual beneficial effect of fungicide applications is still noticeable even though the spraying ceased four years ago.

Blister blight

Screening of fungicides

Ten formulations were used to test their efficacy in controlling Blister blight in one trial. Four rounds were applied at weekly interval to plots of 40 bushes each (4 replications), immediately following a plucking round.

The data on blister blight infection during the 3rd week after the fourth round of spraying is given in Table 7.

Table 7. Efficacy of different fungicides in reducing infection by Blister blight.

Treatments	Rate kg/ha	Percentage shoot infected	% reduction over control
1. Dikar	2.5	4.75	76.25
2. Difolatan	2.5	3.25	83.75
3. Dithane M 45	2.5	2.25	88.75
4. Dithane C 90	2.5	2.75	86.25
5. Hoe 6052 Sicarol 50WP	300 g	0.75	96.25
6. Starcop	2.5	1.50	92.50
7. TOC 156	2.5	2.25	88.75
8. TOC 157	2.5	3.50	82.50
9. Blitox + Idet	2.5	0.25	98.75
10. Blitox	2.5	1.00	95.00
11. Control		19.75	
CD at P = 0·05	4.37		
CV %	73.8		

Average of 100 shoots.

All the chemicals have given excellent control, but the 1973 season being not quite typical of Darjeeling, being warm and rather dry, it would be interesting to study their performance in a typically wet Darjeeling condition.

Reduced dose of fungicide vs. Blister blight

In one experiment a copper oxychloride (Blitox) was sprayed on five occasions at weekly intervals at 2.5 kg/ha; 1.25 kg/ha and 0.625 kg/ha. The percentage shoot infection recorded in the third week following the final round of spraying, is tabulated below:

Table 8. Control of Blister blight achieved at different rates of Blitox spray.

Treatments	Per cent shoots infected	% reduction
A. Blitox at 2.5 kg/ha	1.0	97
B. Blitox at 1.25 kg/ha	0.6	98
C. Blitox at 0.625 kg/ha	4.2	87
D. Untreated control	32.8	
CD at P = 0.05	4.3	
CV %	32.0	

The efficacy of the doses needs further testing under typically wet Darjeeling conditions as indicated in the earlier experiment.

Primary root rot diseases

An experiment on the control of primary root rot diseases with soil fumigants and systemic fungicides has been initiated in a garden known to be affected by primary root rots. The chemicals used are Vapam, Dichloroethylene, Telone, Calixin and Bavistin.

Four soil fumigants viz. Shell DD, Vapam, Telone and Dichloroethylene are being tried against Charcoal stump rot caused by *Ustulina zonata*.

Purple root rot

No mortality has been recorded from any of the experimental plots including the control plots. Chemical treatments were administered to some of the plots to study their effect on the development of the fungus, *Helicobasidium compactum*.

New records

A new blight on TV 18 clonal nursery

In 1973 one of our nurseries of clone TV18 was found suffering from a hitherto unrecorded disease. Leaves developed a scorched appearance primarily from the tips which extended to almost three-fourths of the lamina. Rarely the tender leaves were first affected. Gradually the distress spread to other leaves, the plants appeared sickly, stunted and finally died. Root, stem and the petiole of the affected plants did not show any histopathological changes. The deaths were enormous.

Spraying of streptomycin at 5 gm/litre, arrested the progress of the diseases, followed by production of new healthy shoots. Further investigation on this disease and its control are in progress.

RESEARCH AND EXPERIMENT

Biochemical differentiation of clones

In our long term project concerning the biochemical differentiation of clones, on the basis of green leaf analysis, alone, which was started in 1969, considerable progress had already been made during the last four years (vide Annual Reports 1969-70, 1970-71, 1971-72 and 1972-73). As a matter of fact, we are in a better position to correlate some of the biochemical factors, namely enzyme activity, QO_2 μl/mg/hour) and oxidisable polyphenols expressed in terms of total oxygen uptake (μl/mg/ 2 hours) of fresh tea shoots with the cup characters of the corresponding black teas. This observation was also verified in this year using another batch of three clones viz. TV 15, TV 16 and TV 17 analysed on weekly intervals throughout the plucking season. Results of these analyses were in conformity with the earlier observation enabling us to rank the three clones in the order of preference as clone TV 17 > TV 16 > TV 15 (Table 1). Enzyme activity and total oxygen uptake increased from TV 15 to TV 16 and then to TV 17. Tasters' findings on the corresponding teas too corroborated our observations. Thus, we are fairly justified in concluding that quality of tea increases with the increase of enzyme activity and total oxygen uptake of the corresponding green leaf and that clones can broadly be ranked in order of preference on the basis of such well defined characters.

Table 1. Ranking of clones on the basis of enzyme activity and total oxygen uptake of green leaf (each figure is the average of 24 repeats).

Clones	Enzyme activity QO_2. μl/mg/hrs.	Total oxygen uptake μl/mg/ 2 hours	Biochemical ranking
TV 17	17.21 ± 0.457	11.25 ± 0.225	1
TV 16	16.77 ± 0.448	10.87 ± 0.211	2
TV 15	15.68 ± 0.423	7.99 ± 0.142	3

Besides these, some of the other chemical components of leaf and made teas were studied simultaneously throughout the season. The constituents studied were polyphenols *viz.* (-) - epigallocatechin, (—) epigallocatechin gallate, (-)—epicatechin gallate and theogallin; amino acids *viz.* aspartic acid, glutamic acid, serine, glutamine, alanine, tyrosine, valine and theanine; and chlorophylls (Sum of 'a' and 'b' chlorophylls) of green leaf and the principal coloured pigments, theaflavins and thearubigins of tea.

Theaflavins and thearubigins were the highest in clone TV 17 and lowest in clone TV 15. This corroborated our biochemical ranking. Theaflavin content of TV 17 had been found to be highest of all the Tocklai released clones so far analysed, being 2.4 to 2.6 per cent in the peak quality period. Our previous observation was that proportionately higher content of ( ) - epicatechin gallate produced higher amount of thearubigins, as was recorded in case of TV 1.

Similar observation was made in TV 16 and TV 17 which have a proportionately higher content of ( ) epicatechin gallate as compared to TV 15. However, it may be mentioned that TV 17, apart from producing high amount of thearubigins, also contained higher amount of theaflavins as compared to TV 1. From these observations, it appears that TV 17 is better in some respects than TV 1, being brighter and brisker in cup infusion because of the high content of theaflavins (Table 2).

Table 2. A comparative study of Theaflavins and Thearubigins contents (%) of some clones (average of 24 repeats).

Components	TV 15	TV 16	TV 17	TV 1
Theaflavins	1.37	1.41	1.91	1.74
Thearubigins	15.66	17.62	18.09	20.00

Of the other components, the total polyphenols in TV 15, TV 16 and TV 17 were almost the same but their distributions were different. Higher concentration of (—)— epicatechin gallate was observed in TV 16 and TV 17 than in TV 15. The ratio of EGCG/ECG in TV 16 and TV 17 was less (1.5)

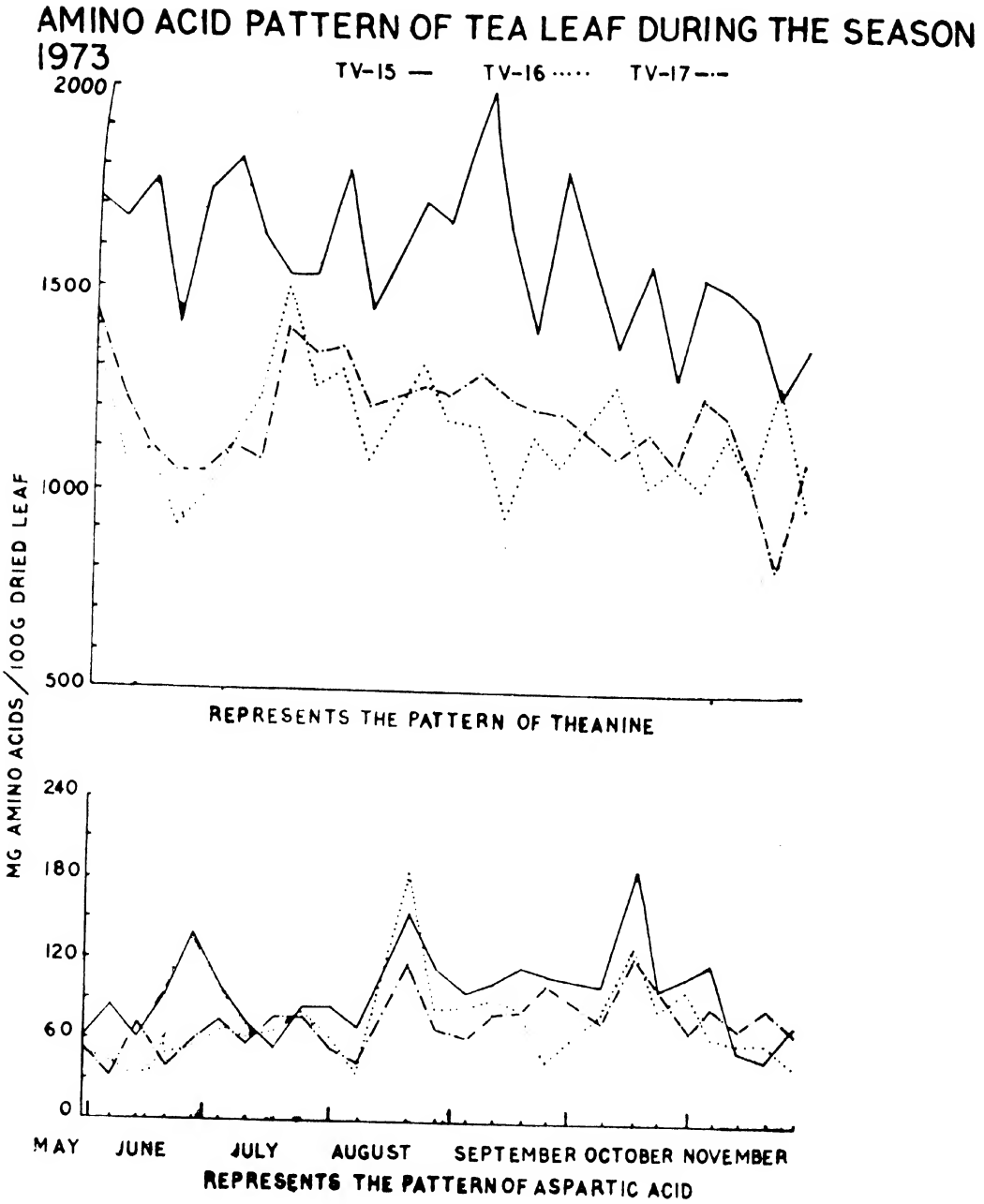
AMINO ACID PATTERN OF TEA LEAF DURING THE SEASON 1973
TV-15 —
TV-16 .....
TV-17 -.-
2000
1500
1000
500
MG AMINO ACIDS/100G DRIED LEAF
REPRESENTS THE PATTERN OF THEANINE
240
180
120
60
0
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
REPRESENTS THE PATTERN OF ASPARTIC ACID

Fig. 1

than that in TV 15 (3.4), indicating that TV 16 and TV 17 are of China hybrid character and TV 15 is of Assam character. The chlorophyll analysis is recorded in Table 3. From these data, it is not possible to correlate the quality of these clones with chlorophyll content. *Further work is in progress.*

Table 3. Variation in chlorophyll (a + b) content of fresh leaf during the season (g/100 g dry weight average of four repeats).

	Clone TV 15			Clone TV 16			Clone TV 17		
Months	a	b	a+b	a	b	a+b	a	b	a+b
June	1.680	1.254	2.934	1.686	1.361	3.047	1.587	1.285	2.872
July	1.690	1.198	2.888	1.985	1.431	3.416	1.685	1.342	3.027
August	1.760	1.513	3.273	2.172	1.566	3.738	2.162	1.590	3.752
September	1.968	1.389	3.357	2.098	1.543	3.641	2.159	1.556	3.715
October	1.938	1.217	3.155	2.012	1.273	3.285	2.329	1.491	3.820
November	1.777	0.933	2.710	2.461	1.268	3.729	2.667	1.326	3.993

Amino acids were highest in clone TV 15, but lowest in clone TV 16. Earlier it was observed (Ann. Rept. 1972-73 p. 64) that the amino acid content was negatively correlated with the tea quality. Although TV 17 was found to be the best amongst the three clones, the concentration of amino acids in TV 17 was higher than in TV 16. The leaves of TV 17 are more brittle and easily damaged so that along with other enzymes, the proteolytic enzymes might act more vigorously resulting in the breakdown of proteins to amino acids to a greater extent (Table 4).

Table 4. Major amino acid components of fresh tea leaf in mg/100 g dried leaf (Each figure is the average of twenty-five repeats during the season from June to November, 1973).

Amino acids Components	TV 15	TV 16	TV 17
Aspartic acid	95.4	71.2	32.3
Glutamic acid	280.0	261.8	379.9
Serine	22.6	23.8	21.4
Glutamine	82.1	38.4	49.7
Alanine	48.1	45.3	52.4
Tyrosine	7.6	9.7	9.8
Leucines	21.8	21.8	20.6
Valine	15.0	14.9	14.1
Theanine	1428.3	981.0	1021.2
Total	2000.9	1467.9	1793.4

Biosynthesis of Polyphenols

Attempts were made to enhance the polyphenolic contents of the tea bushes with a view to improving the quality of the leaf. In a modest way, a few chemicals were tried in the tea bushes in the form of foliar spray to tap the biosynthetic pathways of polyphenols. Subsequently, the polyphenolic contents of the leaf and the quality of the corresponding teas were studied. Positive results were obtained in certain cases, but large scale experimentations are necessary before arriving at a definite conclusion.

The pigment profiles as an index of flushes of North East Indian plain teas (black)

The object of this experiment was to correlate the pigment profiles with the flushes (viz. first,second, rains and autumn) of North East Indian plains teas.

About one hundred black tea samples manufactured from clones TV 1, TV 2, TV 9 and TV 18 throughout the manufacturing season of 1973, were studied for their pigment profiles in collaboration with Sheffield University.

The tea samples were extracted with aqueous acetone and the extracts passed through a Sephadex LH-20 column. The eluate was passed through a 'flow through' cell at 384 n.m. and elution diagram (record of 8 eluates) provided the pigment profile of the sample. Fractions A, B, C_1, C_2, C_{3_1}, C_{3_2}, D and E were then collected in a fraction collector, evaporated to dryness, weighed and examined by paper chromatography.

The pigment profiles of the above teas were of almost similar nature, but varied only in C_1 and C_{3_1} fractions. These fractions produced shoulders in the pigment profiles which varied from flush to flush (Fig. 2).

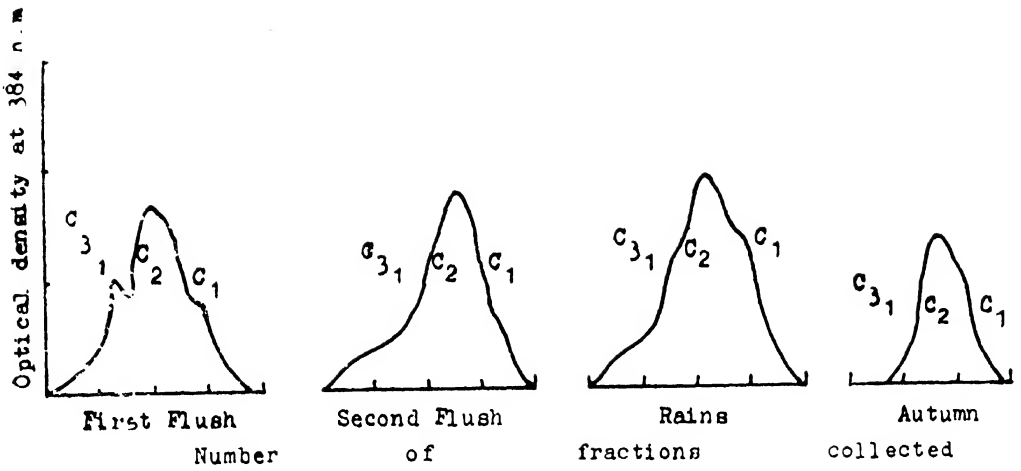

Fig. 2

The first flush was characterised by the presence of the prominant shoulders C_1 and C_{3_1} in the pigment profiles. It was found that chlorogenic acids and chlorophylls were mainly responsible for C_1 and C_{3_1} shoulders, respectively, in association with thearubigins and some other minor chemical constituents.

In the second flush chlorogenic acids and chlorophylls were present in a harmonic combination and it was characterised by the absence of shoulders at C_1 and C_{3_1}. In rains tea C_1 shoulder re-appreared but it was not so prominant as in the first flush. Sometimes this flush was also characterised by the presence of C_{3_1} shoulder. In this case chlorogenic acids and chlorophylls were not in harmonic combination. In autumn flush, similar pattern of pigment profiles as in the 2nd flush was observed but with a less amount of chemical constituents.

On analysing the pigment profiles of teas of clones TV 18 and TV 9, it was observed that the second flush character (absence of shoulders at C_1 and C_{3_1}) developed in TV 18 and TV 9 on 28.6.73 and 7.7.73 respectively. Before these dates, the teas were of mainly first flush character (shoulders at C_1 and C_{3_1}). The second flush character was more pronounced in TV 18 than TV 9 and began to diminish in TV 18 and TV 9 from 12.7.73 and 14.7.73 respectively, indicating the disappearance of the main quality period (peak second flush). The main quality period of this manufacturing season (1973) was of a short duration and the rains character developed around the second week of July. In case of TV 1 (Fig. 3), a characteristic of an inferior tea was observed after 26.7.73, thus showing that the quality of TV 1 was affected during the rains. A similar observation was made in TV 2. Disappearance of shoulders at C_1 and C_{3_1} in pigment

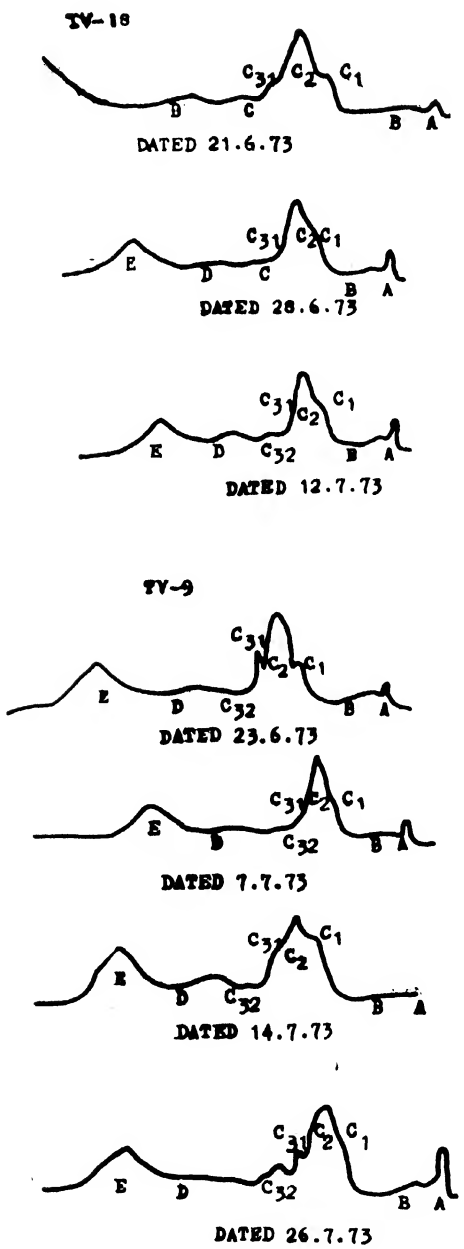

Fig. 3

profiles showed that the clones regained their quality to a certain extent in the third week of August indicating the appearance of autumn flush.

It may be concluded in the most general way that the shoulders C_1 and C_3 of the pigment profiles were associated with inferior quality teas and these gradually disappeared with the improvement of the quality of tea and were completely absent in the peak quality period of second flush. With the onset of second flush, the rawness in the cup infusion, detected by the tea taster in the first flush teas, disappeared slowly and ultimately the second flush characters developed in the peak quality period with the complete disappearance of rawness. The peak second flush period varied from source to source. The shoulder C_1 gradually reappeared (C_3 shoulder being negligible or absent) during rains in these clones. The concentration of chemical constituents was less in autumn flush than in other flushes. It was further observed that during autumn, theaflavin mono-and di-gallates which are comparatively less coloured substances, were more than the theaflavin, the most golden yellow coloured substance which is mainly responsible for brightness and tone of the colour of tea liquor. This appears to be one of the reasons why the tone of colour is lacking in the autumn flush teas.

Miscellaneous Experiments

(a) **Analysis of tea samples**

One hundred one tea samples from Tea Tasting Department, Research Engineering Department and various Tea Estates were analysed during the year.

(b) **Moisture meters**

Five infra-red moisture meters from different Tea Estates were calibrated during this year.

Tea Tasting Department

Dual Manufacture

During the year under review attempts were made to find out the performance of some of the Tocklai released clones on dual manufacture. For this experiment 2 kg leaf samples of clones TV1, TV9, TV10, TV12, TV16, TV17 and Stock 450 were manufactured in the miniature factory.

Fresh leaf having a wither of 70% gave about 31% recovery from withered leaf to made tea. The withered leaf was rolled for 30 minutes in 1 kg pizey roller. After 30 minutes roll with sufficient pressure to express juice on the table the leaves were sifted by sieve No. 6 and about 15% fines were extracted for making of orthodox tea. The remaining leaves were passed twice through the C.T.C.s.

The orthodox fines and the C.T.C. samples were fermented for 3 hours and 1 hour 40 minutes respectively including rolling time.

The orthodox fines were dried for 55 minutes with an inlet temperature of 93.5°C (200°F) while C.T.C. samples were dried for 30 minutes at the same inlet temperature. Thereafter, orthodox bulk grade was made by passing the mal through sieve No. 14 and over sieve No. 36.

Samples from the above were taken and tasted by the Calcutta, London and Tocklai Panels of Tasters on 20 occasions (reports from Calcutta panel received on 6 occasions only). The average valuations obtained by different clones from these tastings are given in the following tables :

C. T. C. Average Value			Orthodox Average Value		
Clones	Tocklai (in Rs/kg)	London (on points)	Clones	Tocklai (in Rs/kg)	London (on points)
TV 1	6.95	5.12	TV 1	6.43	5.29
TV9	6.07	2.35	TV9	5.95	3.18
TV10	6.05	5.94	TV10	5.66	4.94
TV12	6.04	3.88	TV12	5.77	3.41
TV16	6.44	6.18	TV16	5.81	5.94
TV17	7.03	6.12	TV17	6.65	6.41
Stock 450	5.94	2.53	Stock 450	5.80	2.47

From the above table it seems that TV1, TV16 and TV17 would be suitable for dual- -orthodox and C.T.C. manufacture. The other three clones and the Stock did not expose much tip and also their cup characters in orthodox manufacture were rather poor.

From this observation it may be noted that the quality of TV17, in a general way is approaching towards that of TV1. But quite significantly the brightness of TV17 is superior to the other clones. It is established again that the strength of TV1 is superior compared to the other clones including TV17. In case of orthodox manufacture the tip content of TV17 is more than the other clones. While evaluating the orthodox teas the leaf appearance and tip content were taken into consideration.

The result of this experiment was statistically analysed and clones TV1, TV16, and TV17 were significantly superior. But this is merely a preliminary exercise and more experiments on this line would yield useful information.

Blending Experiment

A preliminary experiment was carried out to find out the potential liquor characters developed by mixing of clonal teas in different proportions during the second flush period. The method of manufacture was C.T.C. and the clones selected for blending were put in three different classified groups. Unsorted tea samples were blended to represent- 1. Strong Assam character 2. Flavoury Assam character 3. Self-drinking character.

The blended teas were sampled under codes and tasted at Tocklai. All these blended teas threw excellent colour in cup and settled down with noticeable creaming index.

In taste, it seemed that 8 parts of TV1 blended with 6 parts of TV5, TV11 and TV12 each with a density of 290 cc. per 100 gm, and 8 parts of TV1 blended with 6 parts of TV3, 8 and 9 each with

a density of 270 cc. per 100 gm produced hard, bright and strong liquors, similar to strong Assam character.

Again, 8 parts of TV1, blended with 6 parts of TV14, TV16 and TV17 each having a density of 290 cc. per 100 gm had a touch of flavour similar to flavoury Assam character.

8 parts of TV16 and equal parts of TV17 blended together had a density of 250 cc. per 100 gm the blend was considered as self-drinking tea.

Long term trial of clones

During the year leaf samples of eight clones of China, Indo-China and hybrid stock were manufactured in the miniature factory both by orthodox and C.T.C. methods for evaluation of cup character. These teas were tasted 16 times at Tocklai and on a few occasions in Calcutta and London by the panels of tea tasters. Three clones were selected on the basis of this manufacturing, and tasting results obtained.

Another set of 14 clones from long term clonal selection were manufactured in the miniature factory both by orthodox and C.T.C. processes. The teas were tasted at Tocklai, Calcutta and London panels of tea tasters. The result of tastings showed that out of 14 clones, TV19, TV20 were consistent in respect of cup character during the last two years, in the tasting of Tocklai Tea Taster. Another set of 46 clones were manufactured by C.T.C. method only. The result indicated that 8 -10 clones had promising cup character. The screening will continue further in the next season.

Biclonal progeny

Four progenies with control were manufactured in the miniature factory by C.T.C. method and on tasting the Tocklai tea taster found these biclonal progenies to have outstanding cup characters.

Flush characters—Tocklai Released Clones

Seventy two samples of teas of TV15, TV16 and TV17 were manufactured by the C.T.C. method once in every week from April to November and the teas were tasted by the Calcutta, London and Tocklai panels of tea tasters. The results of tasting were rated in order of merit as TV17>TV16>TV15 in cup quality throughout the season.

Quality experiment

Forty four samples were tasted by Tocklai, Calcutta and London panels of tea tasters. The experiment is being continued.

Testing of Commercial Products

The following commercial products were tested:

1. Deep-clean (liquid detergent) sent by Messrs D.M. Industries (India) Ltd., Calcutta.

2. Pervenol — N (detergent and cleaning agent) sent by Messrs Industrial Sales & Agency, Calcutta.

3. Liquid detergent sent by Banshidhar Sewbhagovan & Co., Rehabari, Dibrugarh, Assam.

All the above products were tried out to find their suitability as cleaning agents for fermenting room floors, green leaf sifters, rollers etc. From the chemical analysis it was observed that all these detergents had high pH value and were considered detrimental for use in tea factories, unless precaution is taken to wash them out after use by flushing with large quantities of water.

Halder brand powder and liquid detergent Both these detergents were tested as cleaning agents in factories. The detergent in powder form was found to be an effective cleaning agent for fermenting floors, rollers, sifters etc. without any adverse effect on the liquors of the made teas. The detergent in liquid form after chemical analysis was found to have a high pH value and was therefore not recommended for use in tea factories.

Non-interleaved Tea Chest Linings : Samples of this product received from Messrs Williamson Magor & Co. Ltd., Calcutta were tried and the following experimental results were obtained.

Teas were stored for 3 months, 6 months and 9 months in plywood tea chests using non-interleaved and normal commercial linings. Samples were drawn after each of the above noted period of storage from the experimental and the control tea chests. The samples were then tasted by the Panel of Tasters in London, Calcutta and Tocklai. On every occasion the control samples were preferred to the experimental samples.

The non-interleaved linings absorbed more moisture than the normal commercial linings, possibly due to its being more porous and the results as *indicated that these linings as replacements to* normal commercial linings could not be recommended.

TEA TASTING AND ESTATE VISITS

Tea Tasting : During the season 4,945 experimental samples from Tocklai, 3,807 samples from estates for advising on manufacture and 1,972 clonal samples from estates were tasted. Besides this, a large number of samples were also tasted during the visit to the factories.

Estate visits and tasting sessions : The Tea Taster visited 15 factories for advising on manufacture and attended 7 tasting sessions.

Engineering Research & Development Department

RESEARCH & EXPERIMENTAL

ROLLING

Continuous Green Leaf Processing Machines

1. **Disc Type Continuous Roller :** The 122 cm (48") Commercial Prototype Disc Roller was installed at Sycotta Tea Estate early in the last manufacturing season for trials on a commercial scale. Coarse 'mal' obtained by sifting the rolled leaf after a 30 min conventional roll was processed in this machine for extraction of second, third and sometimes fourth fines with great success. The estate when on pure orthodox manufacture, passed almost the entire leaf through this machine whenever withers were reasonable. The speed of the worm was reduced from 22 r.p.m. to 15 r.p.m. and the disc speed was reduced from 15 to 8 r.p.m. A new set of battens of a more advanced design was fitted to the machine in the first week of July and that improved the appearance and make to a remarkable extent. The throughput of once rolled leaf through the machine at this reduced speed was 1400-1500 kg/hr. The Manager of the estate reported "I am happy to report that after making the necessary alternations in batten design and the speed of the machine, the results show a better leaf appearance having more twist thereby improving the percentage of leaf grades".

Day to day samples of various fractions obtained through the Disc Roller were compared against those from conventional three crank rollers. The results as obtained are shown in the following table :

Average valuations of Dryer mouth teas (Rs./kg) by Tocklai Tea Taster.

Month	2nd fines Disc	2nd fines Conventional	No. of Comparative samples tasted	No. of times Disc was preferred
May	5.96	5.99	12	7
June	5.88	6.08	18	6
July	6.21	6.05	13	8
August	6.00	6.03	11	5
September	5.71	5.81	21	8
October	6.23	6.31	13	6
November	6.19	6.27	13	6

The above assessment of unsorted drier mouth samples indicate that the Disc Roller samples are very similar to those from conventional rollers.

From what the manager has stated and from our own observations, it appears that the Disc Roller as developed can easily supplement conventional rolling tables in orthodox factories for second and subsequent rolls. This will reduce the number of rollers required and also reduce the horse power and space requirement in orthodox factories. The Disc Roller has now been sent to Port Engineering Works, Howrah to serve as a sample for them to copy and to enable them to incorporate the latest batten design in the commercial models to be manufactured by them.

2. **Barbora Continuous Leaf Conditioner :** It has been ascertained from the manufacturers, M/s. Port Engineering Works that so far the following machines were installed in commercial factories during the last manufacturing season. The latest figure regarding the number of machines sold so far is not available with us.

Powai (Upper Assam) ..	.. 3 Nos.
Nahortoli (Upper Assam)	.. 2 Nos.
Subhasini (Dooars) ..	.. 1 No.
Caroline (South India)	.. 1 No.
Borojalingah (Cachar) ..	.. 1 No.
Midland Rubber (South India)	.. 1 No.

Cutter attachment for B.L.C.

The 15" commercial size B.L.C. sent to Tocklai for trials by its manufacturers M/s. Port Engineering Works was fitted with a Cutter Attachment. The cutter was made from Stainless Steel Plates. In the course of trials it was found that plate-cutters wear out quickly and also they lead to some amount of heat generation due to rubbing action. Preliminary set of comparative experiments at Tocklai with the B.L.C. with plate-cutter + 1 cut C.T.C. and Rotorvane + 2 cuts C.T.C. manufacture gave the following results according to Tocklai Taster :

Average valuation : BLC with Plate Cutter + 1 cut CTC Rs. 5.42
Rotorvance + 2 cuts CTC —Rs. 5.85

The design of the cutters was since changed to fabricated cutter with ribs. The changeover has resulted in lowering of temperature in the cut leaf and the machine performance was considerably improved.

The cutter plates have since been replaced by fabricated ribbed cutters and the machine was tried at Hunwal Tea Estate where the B.L.C. + cutter + 2 cuts C.T.C. method was compared to the estate's Roller + 3 cuts C.T.C. method of manufacture. The results as obtained are shown in the following table :

Average Valuations of Dryer mouth teas.

Month	BLC + cutter + 2 cuts CTC	Roller +3 cuts CTC	No. of Comparative Samples tasted	No. of times BLC +Cutter +CTC preferred
October	6.25	6.35	6	2
November	6.34	6.38	16	7
December	6.36	6.12	4	3

Comparative invoices from B.L.C. cutter + C.T.C. teas and Hunwal's, normal Roll/C.T.C. teas were sent to Calcutta Auctions. The B.L.C. + Cutter + C.T.C. invoice realised 40 p. higher price than the comparative normal Hunwal C.T.C. invoice. The auction prices were Rs. 8.60 for B.L.C. Cutter + C.T.C. against Rs. 8.20 for Hunwals % normal Roll/C.T.C. invoice.

The machine with the cutter attachment has since been sent back to Port Engineering Works as a sample for them to copy.

3. **Leaf Sizer Attachment with Rotorvane :** Following trials at Meenglas Tea Estate the attachment has been shifted to Lakhipara Tea Estate in Dooars. The Agency has requested for 3 more cutter attachments for trial in their other estates on Rotorvane/C.T.C. manufacture. The Visiting Agent for Lakhipara Tea Estate had since reported to us regarding this experiment in the following terms.

"The cutter attachment has been working on an experimental basis at Lakhipara this year. The results obtained so far are as follows :

1. There has been no reduction in throughput.
2. The appearance of made tea shows improvement over the conventional method.
3. The grade percentage shows a slight improvement. While broken percentage remained unchanged, the fannings have been reduced and dusts have increased.
4. The liquors are brighter and brisker than the conventional."

He also mentioned about the problems experienced by us viz. :

(a) due to constant rubbing of blades against plates the plates are being eaten up and are breaking down,
and (b) that arrangement for charging of the machine should be streamlined.

The problem relating to cutter plates has since been solved by using cutter blades of fabricated construction as earlier reported on in connection with cutter attachment for B.L.C. The mounting has also been redesigned to accommodate the fabricated cutter plates and to make changing of cutter plates comparatively easier and quickly.

4. **Continuous Tea Roller :** In an attempt to make conventional orthodox type of tea in a continuous manner a pilot model of a new type of roller was designed, constructed and tried out in the department by the Second Research Engineer during the year. The machine essentially consists of a horizontally placed reciprocating cylinder closed at one end by a fixed block and a frusto-conical "rotor" or oscillating member making angular oscillations around its own axis placed concentrically within the cylinder. Withered leaf fed intermittently at one end of the cylinder through a hopper is rolled

in the annular space between the inner wall of the cylinder and the outer wall of the rotor. Processed leaf is discharged through the mouth of the cylinder at the other end. Preliminary trials have shown that the teas produced by this machine are very similar to the conventional orthodox teas in respect of both appearance and liquor characters. The valuation of the teas produced during the trials to compare the processing action of this prototype machine with that of a conventional three- crank roller at Tocklai are given below :

Average Valuations of dryer mouth teas : Rs./kg.

Month	1st fine		2nd fine		3rd fine		coarse	
	C.T.R	Conventional	C.T.R	Conventional	C.T.R	Conventional	C.T.R	Conventional
May	5.61	6.26	5.58	6.16	5.74	6.32	5.26	6.10
June	5.17	6.57	4.94	6.02	4.70	5.56	4.17	6.00
July	5.97	6.60	5.80	6.60	6.02	6.57	5.00	6.00
August	5.35	5.33	5.33	5.33	4.05	5.50	4.67	4.83

With the experience gathered during the course of the trials the machine has now been set as given below :

Stroke length of cylinder = 8"
Speed of cylinder = 50 reciprocations/min.
Amplitude of rotor oscillations = 180°
Speed of rotor = 25 oscillations/min.

The relative disposition of the cranks for driving the cylinder and the rotor is set to give such a relative motion between the two that gives the best possible rolling action on the leaf within the limitations of the mechanical design of the machine. The action on the leaf not only causes the leaf to roll against the cylinder and rotor walls, but also causes a good amount of leaf to leaf action between the leaves themselves which is one factor responsible for producing conventional orthodox type of teas. Further trials with this model having a 37.5 cm dia cylinder set as above early in 1974 season has shown improvement both to the appearance and liquor, while giving an output of 400 kg/hr and consuming only about 5.5 H.P.

With a view to trying out and developing the machine under commercial conditions a 45 cm (cylinder dia) prototype commercial model is being made during the end of the year, incorporating the ideas gained from the experience with the prototype during the last manufacturing season. The construction of this prototype is expected to be completed by the middle of April when it will be shifted to Towkok Group of Tea Estates for commercial trials during the coming season.

Applications for a patent for this machine are already submitted in various countries.

Fermentation

Continuous Machine : Preliminary trials with the S.F. version of the Tocklai Continuous Fermenting Machine installed at Ethelwold Tea Estate indicated certain areas where the design can be modified to improve its performance and operation. These modifications are being incorporated by the manufacturers, S.F. (India) Ltd., to obviate the apparent drawbacks in their design.

Plucking

Manual Plucking Aid : With the design modifications suggested by the Senior Research Engineer some further progress has been made by Shaw Wallace & Company of Madras in development of the plucking aid operated by a two stroke petrol engine. The first unit of this design was inspected by the Senior Research Engineer in Madras. Some further improvements to its mechanical action and design details were suggested. One or two commercial units fabricated at the Madras Works of Shaw Wallace & Company which were to be made available to Tocklai before the end of the manufacturing season are still awaited. Requests from a number of Group Managers have been received for this Plucking Aids for commercial trials in their respective areas.

Resume of the Work done on Physical and Chemical characteristics of Plucking Tea shoots.

Research work conducted by the C.S.I.R. Research Fellow under the guidance of the Senior Research Engineer may be summarised as follows :

Anatomical observations were made into leaf and stem structure of tea shoot at different moisture contents to analyse the withering mechanism.

The factors responsible for controlling the rate of evaporation of moisture from tea are grouped under external and internal factors. Some physical and anatomical studies were also made.

The external factors are -
(a) Pore spaces within the plant material,
(b) density,
(c) temperature,
(d) humidity,
(e) air velocity
and the internal factors are—
(a) availability of water,
(b) permeability of cellular wall,
(c) pressure gradient in the intercellular spaces,
(d) permeability of the outer integument,
(e) length of diffusion paths,
(f) stomatal opening etc.

A series of experiments carried out to study the change in volume and bulk density of tea shoots with the change of moisture content gave a highly significant correlation between volume and moisture content.

An analysis was made to determine the power requirement to deform the stems of tea shoots at different moisture contents. For this purpose an apparatus was designed and adapted. With that apparatus, analysis has shown that the force required for rolling depends upon six factors, viz. :

(a) diameter of the material to be rolled,
(b) roller diameter,
(c) mechanical properties of the material to be rolled,
(d) roller speed,
(e) co-efficient of friction between the rollers and (f) desired reduction of size after a single pass through the rollers.

Results obtained from this set of experiments showed a highly significant correlation between power requirement to deform the stem and moisture content of the stem.

Further work on the above lines are being continued.

General

The Senior Research Engineer attended two meetings of I.S.I. on standardisation of Pest Control Equipment. He was also a member of the Indian Delegation to the International Standards Organisation and attended the meetings of standardisation of tea and instant tea in the International Standards Organisation meetings held in New Delhi in February, 1974. He visited Madras once in connection with fabricated engine-powered manually carried plucking aid and Calcutta twice for consultation with the Association's Licencees manufacturing machinery designed and developed by Tocklai. The Senior Research Engineer went to New Delhi to receive the award and certificate for meritorious invention on 15th January 1974 from Sri C. Subrahmanyam, Minister for Industrial Development, Science and Technology, Government of India at the presentation ceremony organised by National Research Development Corporation for the purpose at the Vigyan Bhavan, New Delhi. He also attended seven Area Scientific Committee meetings of North Bank East, North Bank West, Darjeeling, Terai, Dooars, Digboi and Sonari. He paid 46 advisory visits to different factories during the year.

The Second Research Engineer attended the Scientific Conference of the UPASI in Coonoor, and visited a number of factories in South India. He paid 9 advisory visits to different factories during the year.

Sampling and Experimental Technique

(i) **Sampling of plucking rounds :** In long-term experiments with tea, the labourer and supervisor engaged in weekly plucking, and recording of individual yields from the experimental plots involve considerable time and expenditure. In order to minimise the time and expenditure without any appreciable loss of experimental accuracy, a study has been taken up to find out whether it is possible to make treatment comparisons from part yield of the whole season or from sample pluckings, taken on fewer occasions. This is most important particularly for those experiments which are laid out in the estates where it is generally difficult and expensive to supervise weighings of plot yields on all plucking rounds throughout the season. Preliminary investigation on this study indicates that whole season's crop may suitably be divided into two parts and each part yield will enable to make the treatment comparisons as efficiently as the whole season. This will, therefore, enable the experimenter to conduct double the number of experiments with the same number of supervisors and labourers. Detailed study is, however, being continued.

(ii) **Analysis technique for long-term experimental data :** Orthodox method of analysis of long-term experimental data showed generally increasing error with the cumulative yields of all subsequent years of experimentation. This was, however, mainly due to the existence of correlation between yield of successive years. As a result of this, the orthodox method of analysis is very likely to cause a loss of information hidden in the data. A study has, therefore, been taken up to develop a technique on the analysis of long-term experimental data which would stabilise and minimise the error and would permit the extraction of information concealed in the data.

Crop-Weather Studies

A study on crop and rainfall data collected through mailed questionnaires from the tea estates in the Dooars, West Bengal was undertaken with the same objective and procedure of analyses adopted for some of the other regions of North-East India which were reported in the Annual Scientific Report for 1971-72, pp. 74-77.

This study in the Dooars was undertaken separately for each sub-district, because preliminary investigations showed variations amongst the sub-districts. The results so far obtained for the Jainti and Kalchini sub-districts, based on the data for the period 1958-72, will be reported here. The data for the year 1969 had to be excluded from the analyses in view of the general strike all over the Dooars during August, 1969.

Jainti Sub-district

The results obtained from the Jainti sub-district revealed that rainfall during November-December of the previous season, January-March, April, May, June and July-September of the current season were the most critical periods, and rainfall during these six periods together contributed about 91 per cent towards the annual yield. This suggests that, when all other factors are constant, the rainfall during these six periods mainly control the annual yield in this sub-district. The relative contributions due to November-December, April, June and July-September rainfall were, however, higher compared to January-March and May rains.

The nature of relationship between different critical cold weather period rains, namely, November-December, January-March and April, and the annual yield suggested that the annual yield increased with the increase in rainfall during November-December up to the observed maximum rainfall of 10 cm, and up to about 13 cm during January-March and 26 cm during April. Although, during November-December the rate of increase in yield was lower at the higher levels of rainfall than at the lower levels, there was a considerable increase in crop up to the observed maximum of 10 cm. Whereas during January-March and April, annual yield declined beyond 13 cm and 26 cm of rainfall respectively.

The study of data showed that in almost all the years rainfall during November-December was much less than 10 cm up to which yield was found to increase. It was also seen that in most of the years, rainfall during January-March and April was lower than the optimum requirements up to which annual yield was found to increase, i.e., 13 cm and 26 cm respectively. These are obvious from Table 1 which shows that the average rainfall during November-December, January-March and April was only 3 cm, 11 cm and 23 cm respectively.

Though the optimum rainfall requirement during November-December could not be determined from the set of data under investigation, but it is clear from these results that, on an average, there is always a deficiency of rainfall in each of these periods by at least 7 cm during November-December of the previous season, 2 cm during January-March and 3 cm during April of the current season (Table 1).

Table 1. Rainfall and quantity of irrigation requirements during critical periods and the estimated gain in annual yield due to irrigation.

Region : Jainti sub-district of Dooars

Critical period	Rainfall in centimetre			Average irrigation requirement with economic return (cm)	Yield of made tea in kg/ha		
	Minimum	Maximum	Average		Actual average	Estimated with optimum irrigation	
						Average	Gain
November to December (Previous season)	0.1	10	3	7			
January to March (Current season)	4	29	11	2			
April (,,)	3	47	23	3	1175	1687	512
May (,,)	23	130	60	Drain out excess water			
June (,,)	60	210	126	,,			
July to September (,,)	185	592	322	,,			
Total irrigation requirement				12			

Rains during monsoon periods are a different matter. The types of relationship between different critical monsoon period rains and the annual yield of tea showed that precipitation received in this district during May and July-September was excessive and the highest yield was observed at the lowest precipitation for these periods. Therefore, optimum requirements of rainfall during these two periods could not be determined from the set of data under investigation. June rainfall showed beneficial effect on the annual yield up to about 113 cm, but beyond that limit yield declined. It was also found that in majority of the years, June rainfall was higher than the optimum requirement of 113 cm. This is obvious from Table 1. These results, therefore, suggest that to avoid detrimental effect of excessive rainfall during May to September on the annual yield, extra water must be drained out.

The types of relationship between annual yield of tea and the critical rainfall periods, discussed above, were based on the following equation which was derived from the set of data under investigation.

$$Y = 445.3204\ \mathrm{Log}_{10}(R_2+1) + 26.9538\ R_3 - 1.0624\ R_3^2 + 53.7527\ R_4 - 1.0397\ R_4^2 - 4.4520\ R_5 + 27.7147\ R_6 - 0.1223\ R_6^2 - 1.8641\ R_7 - 301.2480 \quad \ldots\ldots\ldots\ldots (1)$$

where Y = annual yield of made tea in kg/ha, R_2, R_3, R_4, R_5, R_6 and R_7 are rainfalls in cm during November-December of the previous season, January-March, April, May, June and July-September of the current season respectively.

This equation (Equation 1) was used to predict the expected gain in annual yield of tea if irrigation was adopted to make up the average deficiencies of 7 cm during November-December of the previous season, 2 cm during January-March and 3 cm during April of the current season, and adequate measures were taken to drain out the excess rain water during the monsoon period from May-September. The corresponding gain in annual yield was estimated at 512 kilograms of made tea per hectare which was equivalent to about 44 per cent gain in annual yield over the actual average yield of Jainti sub-district (Table 1).

Taking into account the corresponding cost of irrigation for replenishing the average deficiencies of rainfall during the cold weather periods, this study has shown that irrigation during November to April would fetch profit in the Jainti sub-district of the Dooars.

Kalchini Sub-district

Rainfall during January-March, April and July-September of the current season was found to be most critical with respect to deficiency (January-March & April) and excess (July-September) of rain water in this sub-district, contributing about 81 per cent towards the annual yield of tea. These suggest that when all other factors are constant, the rainfall during these three periods are mainly controlling the annual yield in this sub-district. Further, the relative contributions due to January-March and April rains towards the annual yield were much higher than July-September rains.

Equation 2 showed the types of relationship between annual yield and rainfall during these three critical periods, which was derived from the set of data under reference.

$$Y = 110.7560\ R_3 - 5.7644\ R_3^2 + 10.4536\ R_4 + 6.6323\ R_7 - 0.0140\ R_7^2 + 104.5879 \ldots\ldots (2)$$

where Y, R_3, R_4 and R_7 represent the same as mentioned in Equation 1.

These relationships suggested beneficial effect of April rainfall on the annual yield up to the highest level of 37 cm observed during this period. Whereas January-March and July-September rainfall had beneficial effect up to about 10 cm and 237 cm respectively, but beyond those limits rainfall showed detrimental effect on the yield. Further, from the data under study it was found that in majority of the years rainfall during January-March was less than the optimum requirement of 10 cm and that during April, in most of the years, it was much less than the observed maximum of 37 cm up to which yield increased. On the other hand, rainfall during July-September was in most of the years in excess of the optimum requirement of 237 cm. This is evident from Table 2 as the average rainfall during January-March, April and July-September was 9 cm, 16 cm and 265 cm respectively.

These results, therefore, show that, on an average, there is deficiency of water during January-March and April by at least 1 cm and 21 cm respectively, and excess rain water during July-September (Table 2). Equation 2 suggests that if irrigation is applied to make up the deficiencies during the specified periods of cold weather, i.e., January-March and April, and special attention

Table 2. Rainfall and quantity of irrigation requirement during critical periods and the estimated gain in yield due to irrigation.

Region : Kalchini sub-district of Dooars.

Critical period	Rainfall in centimetre			Average irrigation requirement with economic return (cm)	Yield of made tea in kg/ha		
	Minimum	Maximum	Average		Actual average	Estimated with optimum irrigation	
						Average	Gain
January to March (Current season)	1	17	9	1			
April („)	0	37	16	21	1434	1804	370
July to September („)	160	374	265	Drain out excess water			
Total irrigation requirement —>				22			

is paid to drain out the excess rain water during July– September, annual yield can be increased in the Kalchini sub-district. By using this equation (Equation 2) average annual yield was estimated to increase from 1434 to 1804 kilograms of made tea per hectare. From the economics point of view also, this study has shown that irrigation during January to April would be a paying proposition in this sub-district, but the profit would be less than that in the Jainti sub-district.

The critical periods of irrigation, average quantity of irrigation requirement in each period and the estimated gain in annual yield of tea due to irrigation for the Jainti and Kalchini sub-districts of Dooars are summarised in Table 3.

Table 3. Critical periods of irrigation, quantity of irrigation requirement and the estimated gain in annual yield due to irrigation for the Jainti and Kalchini sub-districts of Dooars.

Sub-districts of Dooars	Average irrigation requirement (in cm)				Estimated per cent gain in annual yield due to irrigation	Remarks
	November to December	January to March	April	Total		
Jainti	7	2	3	12	44	Profitable
Kalchini	Nil	1	21	22	26	Profitable

It is, however, necessary to stress that (i) gain in yield due to irrigation would primarily depend on the period of irrigation, quantity of irrigation in each period as shown in Table 3, and draining out the excess rain water during the critical monsoon periods. (ii) While the results presented here represent the average effect of the rainfall factors of the sub-district as a whole, variations from estate to estate within the sub-district with respect to such factors as distribution of rainfall, soil type and depth of soil are quite likely. Therefore, before taking any large scale irrigation programme in the Jainti and Kalchini sub-districts of Dooars, there is need of a careful examination of the rainfall distribution in the past and the characteristics of the soil for each individual estate; and (iii) *irrigation requirement as suggested need to be tested by actual field experiments before large scale programme is adopted.*

Survey on Field Management and Environmental Factors Affecting the Yield of Tea

(i) **Dooars and Terai, West Bengal :** Scrutiny, coding, code checking of the survey data, card designing, punching of the data on cards, verification, listing, list checking and taping of the data have been completed. Writing of programmes in COBOL language and testing of the same on an ICL 1901A electronic computer at Digboi are being continued to analyse this large mass of data. The object of this survey was reported in the Annual Scientific Report for 1972-73, p.79.

(ii) **Darjeeling, West Bengal :** Computerised questionnaire has been prepared to collect data on yield, fertilisers, type of planting, plant population, type of tea, age of tea, soil type, vacancy percentage, aspect, elevation and various other field management and environmental factors from the estates' records and from the field for last 20 years and for each section in all the member estates in Darjeeling. The survey will be carried out shortly. The object of the survey is the same as outlined earlier in the Annual Scientific Report for 1972-73, p. 79 for Dooars and Terai survey.

Long-term Survey-Experiments on Defoliation

Further analysis of the data collected from 1963 to 1972 in the Dooars showed no loss of annual crop due to red spider infestation up to about 10 per cent of leaves infested during the peak period of infestation, i.e., during April and May. But, beyond this level of infestation, there was loss in crop and that loss persisted for the rest of the cropping season. This suggests that the control measures against red spider must be taken before the percentage of leaves infested crosses 10 per cent.

Trends in fertiliser use : Fertiliser use data received from the tea estates of North-East India were compiled and analysed with the following results.

(i) **Nitrogen :** About forty three per cent (470 tea estates) of the total tea estates in Assam, North Bengal and Tripura reported their nitrogen requirement for 1974, which covered about 58 per cent (159639 ha) of the total area under tea in North-East India. In almost all the districts the rate of application of nitrogen was gradually increasing with the years. The rate of application was, however, varying from district to district. The requirement of nitrogen for 1974 of these reporting tea estates averages 118 kg/ha. This is 17 kg/ha more as compared to the rate of application during 1973. The corresponding rates for 1970, 1971 and 1972 averaged 92, 97 and 102 kg/ha respectively.

(ii) **Potash :** About thirty nine per cent (430 tea estates) of the total tea estates in North-East India reported their potash requirement for 1974, which covered about 55 per cent (150681 ha) of the total area under tea in North-East India. The requirement of potash for 1974 of these reporting tea estates averages 45 kg/ha which is 6 kg/ha more than the rate of application during 1973. The corresponding rates for 1970, 1971 and 1972 were about 14, 20 and 30 kg/ha respectively. Furthermore, in almost all the districts the rate of application of potash was found to increase with the years, but it was varying from district to district. In general, the lowest rate was found to be in the Darjeeling and Jalpaiguri districts and the highest was in the Goalpara and Cachar districts.

Help to Other Departments

The Department continued to extend co-operation and help in solving statistical problems encountered by research workers of practically all the Departments of the Station. In order to carry out investigations on different aspects of tea, a number of new experiments were planned and designed during the year. To meet the specialised requirements of these new experiments, complicated statistical designs such as Central Composite Rotatable Design, Systematic Design, Balanced Incomplete Block Design and other non-routine measures had to be introduced.

Library and Publication Department

LIBRARY

General

New journals numbering 16 were added to the subscription list.

Reorganisation

Catalogue Cards and book Cards were being prepared as usual. The journals section was reorganised for ease of reference. However, space and staff shortage continues to be a problem.

Loan Service

The Tea Science students of under and post graduate classes of Assam Agricultural University utilised the Library as in the previous years in addition to Tocklai Scientific Staff. Cases of tearing away pages and non return of borrowed books have again caused loss of valuable reading material. Steps are being taken to avoid a recurrence.

Library Statistics

Total No. of books—3766
Books added during the year—130.
Periodicals and Journals received—1369
New Journals—16
Pamphlets and Bulletins—678
Photocopy—1
Publications consulted in the Library—2784
Publications issued to Departments—623

PUBLICATIONS

The activities of the Publication Section continued to increase.

The following publications were issued from Tocklai :—

(1) **Two and A Bud** Vol. 20, Nos. 1 and 2.
(2) **Advisory Leaflet**

No. 7— Cockchafer : The Damage Caused and Protection of Young Clonal Plants.

No. 8— Efficient Use of Nitrogenous Fertilizers in Tea Under Limited Availability.

No. 9— Planting Material For Darjeeling Estates.

(3) **Advisory Bulletin**
No. 6— Planting Calender for Darjeeling.

(4) **Miscellaneous Reports**
T.R.A. Annual Scientific Report for 1972-73 ; Engineering Research of Development Department Quarterly Reports for quarters ending June, Sept., December, 1973 and March, 1974.

Wall Chart on Recommendations for Control of Pests and Diseases of Tea and Shade Trees with Power Sprayers, December, 1973.

Appendix-A

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
By
THE ADVISORY DEPARTMENT

SOUTH BANK, ASSAM

Project	Site	Index No.	Years of Starting
Soil Rehabilitation	Sangsua T.E.	AS 103	1972
N.P.K. Manuring	Panitola T.E.	AS 108	1973
	Thowra T.E.	AS 111	1973
	Rupai T.E.	AS 114	1973
	Diffloo T.E.	AS 120	1973
Shade	Thowra T.E.	AS 110	1973
	Bordubi T.E.	AS 113	1973
	Methoni T.E.	AS 119	1973
Zinc	Panitola T.E.	AS 109	1973
	Sepon T.E.	AS 112	1973
	Doimukhia T.E.	AS 115	1973
	Bokakhat T.E.	AS 121	1973
Urea	Ducklungia T.E	AS 125	1973

NORTH BANK, ASSAM

Project	Site	Index No.	Years of starting
Plucking & Pruning	Tarajuli T.E.	AN 101	1971
	Dhulapadung T.E.	AN 102	1971
N.P.K. Manuring	Monabari T.E.	AN 116	1973
	Nahoroni T.E.	AN 123	1972
Shade	Partabgarh T.E.	AN 118	1973
	Dhulapadung T.E.	AN 122	1973

CACHAR, ASSAM

Project	Site	Index No.	Years of starting
N.P.K. Manuring	Silcoorie T.E.	C. 38	1973
	Longai T.E.	C. 39	1973
Shade	Arcuttipore T.E.	C. 42	1973
	Pathemera T.E.	C. 43	1973
Soil climatological survey	Coombergram T.E.	C. 20	1962
Zinc	Silcoorie T.E.	C. 40	1973
	Longai T.E.	C. 41	1973

DARJEELING, WEST BENGAL

Project	Site	Index No.	Years of starting
N.P.K. Manuring	Chongtong T.E.	Dj. 34	1973
	Nagrifarm T.E.	Dj. 35	1973
Nitrogenous fertilizer	Lingia Tea Estate	Dj. 29	1967
Pruning	Phoobsering T.E.	Dj. 24	1965
	Maharani T.E.	Dj. 27	1966
Soil climatological survey	Nagrifarm T.E.	Dj. 19	1961
Zinc	Arja T.E.	Dj. 32	1973
	Sungma T.E.	Dj. 33	1973

DOOARS & TERAI, WEST BENGAL

Project	Site	Index No	Years of starting
Rehabilitation of land	Bhogot Pore T.E.	D. 27	1964
	Grassmore	D. 28	1964
N.P.K. Manuring	Bagrakot T.E.	D. 55	1973
	Samsing T.E.	D. 56	1973
	Nimtijhora T.E.	D. 57	1973
	Gungaram T.E.	Tr. 7	1973
Nitrogenous - ertilizer	Baradighi T.E.	D. 33	1966
Cultivation & Weed control	Chuapara T.E.	D 42	1970
Soil climatological survey	Nya Sylee T.E.	D. 24	1962
Shade	Nya Sylee T.E.	D. 9	1953
	Gandrapara T.E.	D. 50	1973
	Dalgoan T.E.	D. 51	1973

Project	Site	Index No.	Years of starting
Infilling	Fagu T.E.	D. 37	1969
	Deundima T.E.	D. 39	1969
	Jainti T.E.	D. 40	1969
	Kartick T.E.	D. 41	1969
	Mohurgong & Gulma T.E.	Tr. 3	1969
	Sahabad T.E.	Tr. 4	1969
Rejuvenation Trial	Dalgaon T.E.	D. 43	1972
	Metelli T.E.	D. 44	1972
	Kilcott T.E.	D. 45	1972
	Rydak T.E.	D. 46	1972
	Kumlai T.E.	D. 47	1972
	Gunjaram T.E.	Tr. 5	1972
Zinc	Kartick T.E.	D. 52	1973
	Baradighi T.E.	D. 53	1973
	Bhogotpore T.E.	D. 54	1973
Potash soil sampling trial	Bêtabari T.E.	D. 49	1973
Clone & Nitrogen Trial	Nagrakata T.E.	D. 48	1973 (H.Q.Expt)

Appendix-B

LIST OF EXPERIMENTS CONDUCTED IN THE MEMBER ESTATES
By
THE OTHER DEPARTMENTS

BOTANY DEPARTMENT

Sl. No.	Experiments	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Trial of biclonal seed stock	South Bank, Assam	Kakajan	AS 206	1966
2.	-do-	North Bank, Assam	Nahorani	AN 202	1963
3.	-do-	-do-	Sonabheel	AN 203	1964
4.	-do-	Dooars, W. Bengal	Bhatkawa	D 201	1962
5.	-do-	do-	Bhatkawa	D 206	1965
6.	-do-	-do-	Hantapara	D 202	1964
7.	-do-	-do-	Meenglass	D 203	1964
8.	-do-	-do-	Rydak	D 205	1965
9.	-do-	Terai, W. Bengal	Hansqua	TR 200	1968
10.	-do-	Darjeeling, West Bengal	Mim	Dj 200	1961
11.	-do-	do-	Ging	Dj 201	1965
12.	Observation plots of biclonal progenies	South Bank, Assam	Abhoyjan		1969
13.	-do-	-do-	Duklingia		1963
14.	-do-	North Bank, Assam	Nonaipara		1966
15.	-do-	Dooars, W. Bengal	Meenglass		1968
16.	-do-	Sikim	Kewzing		1969
17.	Plucking expts.	South Bank, Assam	Duklingia	AS 208	1971

ENTOMOLOGY DEPARTMENT

Sl. No.	Experiments	Location of Estate	Site (T.E.)	Index No.	Year started
1.	Red slug trial	Dooars, West Bengal	Kumargram	6	April, 1973
2.	Red slug trial	North Bank, Assam	Addabari		April, 1973
3.	Red spider trial	South Bank, Assam	Boisahabi		,,
4.	Red spider trial	South Bank, Assam	Dahingcapar		,,
5.	Red spider trial	South Bank, Assam	Kanikor Dalim		,,
6.	Scale Insect trial	Darjeeling	Geille		July, 1973
7.	Scarlet mite trial	Dooars, West Bengal	Hantapara		,,
8.	Cockchafer trial	Dooars, West Bengal	Dalgoan		,,
9.	Trial on Bark-eating borer	South Bank, Assam	Cinnamara		September, 1973
10.	Control trial on Mites	South Bank, Assam	Deha		February, 1974
11.	Termite trial	South Bank, Assam	Dahingcapar		March, 1974.
12.	Cockchafer Studies	North Bank, Assam	Durrung		May, 1973
13.	Cockchafer Studies	North Bank, Assam	Borgang		May, 1973
14.	Cockchafer Studies	North Bank, Assam	Sonajulie		May, 1973
15.	Effect of weedicides on termite infestation	North Bank, Assam	Borgang		January, 1974
16.	Distribution of scarlet mite under shaded and unshaded conditions.	South Bank, Assam	Sooklatinga		1973/74
17.	Incidence of pink mite on pruned and skiffed teas	South Bank, Assam	Nagadhoolie		1973/74
18.	Red spider trial	Dooars, West Bengal	Dalsingpara		March, 1974
19.	Control trial on Scarlet and Purple mite	Dooars, West Bengal	Birpara		,,
20.	Red spidertrial (palliative)	Dooars, West Bengal	Hansqua		,,
21.	Red Spider trial (palliative)	Dooars, West Bengal	Nimtijhora		,,

MYCOLOGY DEPARTMENT

Sl. No.	Experiments	Location of Estate	Site (T.E.)	Index No.	Year started
1.	To assess the effect of spraying standard, copper formulation in 4 rounds during the sporulating period of red rust at lower concentration.	South Bank, Assam	Hunwal	MR 011	1973
2.	Screening of different formulations against Red rust using power sprayer.	,, ,, ,,	Cinnamara	MR 012	1973
3.	Screening of different formulations against Red rust using Hand sprayers.	,, ,, ,,	,,	MR 013	1973
4.	Application of a systemic fungicide against Thorny stem blight.	Darjeeling	Balasun	MC 005	1970
5.	Testing of a new fungicide against Thorny stem blight at different concentrations.	,,	Happy Valley	MC 006	1973
6.	Screening of fungicides against Black rot	South Bank, Assam	Sycotta	MB 010	1973
7.	Efficiency of spraying against Black rot	North Bank, Assam	Ghoirallie	MB 002	1968
8.	Screening of fungicides against Blister blight	Darjeeling	Tukvar	MF 001	1973
9.	Effect of application of copper fungicide at reduced rate in controlling Blister blight.	,,	Bloomfield	MF 002	1973
10.	Chemical control of Charcoal stump rot.	South Bank, Assam	Naharkatia	MP 002	1973
11.	Chemical control of Purple root rot	North Bank, Assam	Baghmari	MP 001	1965

STATISTICS DEPARTMENT

Sl. No.	Project	Site (T.E.)	Index No.	Year started
1.	Uniformity trial	Bokahola (South Bank, Assam)	—	1963
2.	Uniformity trial	Nagri Farm (Darjeeling, West Bengal)	—	1964

ENGINEERING RESEARCH & DEVELOPMENT DEPARTMENT

Sl. No.	Experiments	Location of Estate	Site (T.E.)	Index No.
1.	48' Disc Roller	South Bank, Assam	Sycotta Tea Estate	E.2
2.	Leaf Sizer Attachment	South Bank, Assam	Hunwal Tea Estate	E.2
3.	Leaf Sizer Attachment	Dooars, West Bengal	Lakhipara Tea Estate	E.2

Appendix-C

Published Papers and papers in the Press

1. Barua, D. N. and Saikia, L. R. (1973). Stock-scion Compatibility in tea (*Camellia sinensis L.*) *J. Hort. Sci. 48*, 339-346.

(Abs. A bud grafting trial was carried out with five clones differing in vigour, using each clone both as rootstock and as scion. The vigour of the clones was assessed in terms of pruning weight per unit area of the pruned bush surface. The magnitude of the difference in vigour between the rootstock and the scion clones was found to be a satisfactory indication of grafting success, provided that the stock was the more vigorous of the two clones. The rootstock influenced the leaf yielding capacity of the scion, but it did not affect the liquor quality of the leaf.)

2. Banerjee, B.(1973). The breeding biology of *Polydesums angustus* Latzel. *Norsk: ent. Tidsskr. 20* : 291-324.

3. Biswas, Ajit K., Sarkar Arup K & Biswas Asim K. (1973). Biological and Chemical Factors affecting the valuation of North-East Indian Plains Teas III -Statistical Evaluation of Biochemical Constituents and their Effects on Colour, Brightness and Strength of Black Teas. *J. Sci. Fd. Agric. 24*, 1457-1477.

(Abs. Regardless of tasters and methods of manufacture five biochemical factors, total oxygen uptake of unprocessed tea shoots and theaflavins (TF), thearubigins (TR), (−)—epigallocatechin gallate (EGCE) and theogallin (TG), of black tea are the main contributing factors of colour of North-East India plains tea. Similarly, three constituents, TF, TR and (−)—epicatechin gallate (ECG) of black tea, are the main factors for brightness.

Four factors, total oxygen uptake and ECG of unprocessed tea shoots and TF and moisture of black tea are the main contributing factors of strength of North-East Indian plains tea.)

4. Jain, N. K. & Agrawal M. C. (1973). Effect of Foliar Spray of Urea at different stages of Tillering in Wheat *Sonara* 64. *Indian J. Agric. Res. 7*, 127-132.

(Abs. Field experiments conducted in Kanpur, for two consecutive years (1967-69) showed that single spray of nitrogen was less efficient in Wheat *Sonara*-64 than split application of the same quantity and two sprays at 30 and 35 days stage gave higher grain yield in comparison to sprayings given at early stages).

5. Tessier-Yandell, J. (1973). More Light on Early Pioneers of Tea in North-East India. *Planters Chronicle* Vol. LXVIII No. 11, 229-230.

(Abs. Charles Alexander Bruce was said to have discovered the tea plant. But, actually the discovery was in 1823 by his elder brother Robert Bruce. Charles undoubtedly did all spade work, particularly after Robert's death, established the fact that tea was indigenous to Assam and a practical commercial proposition. Also some credit goes to Charlton and Jankins who had to deal with all the correspondence and convince Calcutta).

Appendix-D

Summary of meteorological observations during 1973

Table 1. Tocklai (Mid Assam)

Latitude : 26.47′ N Longitude : 94° 12′ E Altitude : 96.5 meters a.m.s.l.

Month 1973	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (Under grass)			Monthly Evaporation	
									Depth				
	Mean Max.	Mean Min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	22.6	11.0	16.8	25.4	6.7	13.3	7	6.1	18.4	18.4	19.2	37.1	63.0
	(22.4)	(9.3)	(15.8)			(21.8)	(5)	(5.8)	(18.7)	(18.2)	(19.0)		
February	24.9	13.5	18.2	29.4	8.7	22.6	11	6.5	20.8	20.4	20.6	51.8	83.6
	(24.0)	(11.8)	(17.9)			(32.4)	(7)	(6.2)	(20.5)	(19.8)	(20.1)		
March	28.8	16.0	22.4	33.8	13.1	28.1	4	7.1	24.0	23.4	23.3	84.8	130.2
	(27.5)	(15.4)	(21.4)			(81.2)	(11)	(6.7)	(24.0)	(23.0)	(23.1)		
April	29.5	20.5	25.0	34.1	19.0	259.7	19	6.3	27.3	26.7	26.4	108.4	146.6
	(28.7)	(18.9)	(23.8)			(190.5)	(16)	(5.9)	(26.8)	(25.8)	(25.6)		
May	30.1	23.0	26.6	33.5	21.5	256.5	23	4.8	28.8	28.4	28.3	93.9	150.2
	(29.9)	(21.8)	(25.8)			(283.6)	(20)	(5.0)	(28.6)	(27.6)	(27.5)		
June	31.4	24.9	28.2	35.1	23.0	474.2	27	3.4	30.2	30.0	30.0	91.1	130.8
	(31.5)	(24.1)	(27.8)			(330.4)	(23)	(4.5)	(30.6)	(29.6)	(29.4)		
July	33.4	25.8	29.6	36.6	23.4	196.6	20	5.5	32.2	31.6	31.1	121.8	174.1
	(32.2)	(24.6)	(28.4)			(383.6)	(25)	(4.7)	(31.4)	(30.6)	(30.4)		
August	32.1	25.1	28.6	35.5	23.1	417.4	20	5.2	31.2	30.8	31.0	100.5	155.6
	(32.0)	(24.5)	(28.2)			(342.7)	(23)	(5.0)	(31.4)	(30.6)	(30.5)		
September	31.4	24.6	28.0	35.2	23.3	225.2	19	5.2	30.7	30.7	30.8	80.8	135.2
	(31.2)	(23.9)	(27.6)			(253.0)	(19)	(5.0)	(30.9)	(30.2)	(30.2)		
October	30.0	21.9	26.0	33.6	17.4	58.9	11	6.7	27.1	28.1	29.1	73.2	125.3
	(29.3)	(20.9)	(25 1)			(117.9)	(12)	(5.6)	(28.4)	(27.6)	(28.2)		
November	26.6	16.5	21.6	29.3	11.5	22.9	9	6.0	23.6	23.8	24.6	45.4	81.6
	(26.2)	(15.1)	(20.6)			(27.3)	(4)	(6.1)	(23.9)	(23.6)	(24.5)		
December	23.2	11.3	17.2	25.3	8.7	43.2	5	6 7	18.9	19.2	20.3	36.2	59.3
	(23.4)	(10.6)	(17.0)			(10.5)	(3)	(6.0)	(20.1)	(19.6)	(20.3)		

Per cent Relative Humidity

Table 1(a). Tocklai

Hours of observations IST	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
0613	93	93	90	90	91	93	90	94	95	95	95	94
	(96)	(95)	(92)	(91)	(93)	(93)	(93)	(94)	(95)	(96)	(97)	(97)
1313	57	56	46	62	70	76	70	74	74	70	62	62
	(58)	(54)	(54)	(63)	(71)	(75)	(75)	(75)	(74)	(72)	(64)	(60)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon readings.
(iii) Penman in mm means Penman estimate of evaporation from an open water Surface.

Summary of meteorological observations during 1973

Table 2. Silcoorie (Cachar)

Latitude : 24°.50′ N Longitude : 92°48′ E Altitude : 39.6 meters a.m.s.l.

Month 1973	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (Under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		Depth 5 cm	Depth 15 cm	Depth 30 cm	Open pan in mm	Penman in mm
January	26.2	10.6	18.4	30.5	7.8	21.5	4	8.2	20.7	19.8	21.4	73.7	83.6
	(25.9)	(11.0)	(18.4)			(20.2)	(2)	(8.0)	(21.4)	(20.7)	(21.4)		
February	29.1	13.9	22.5	30.9	9.4	92.2	4	7.9	24.1	22.6	23.6	85.0	105.2
	(27.4)	(12.8)	(20.1)			(52.5)	(4)	(8.1)	(23.1)	(22.0)	(22.4)		
March	30.6	15.6	23.1	38.1	11.9	17.1	4	8.2	27.0	25.2	25.4	106.3	145.5
	(30.8)	(16.4)	(23.6)			(104.8)	(7)	(8.0)	(26.9)	(25.5)	(25.5)		
April	32.5	20.6	26.6	37.1	18.5	443.9	17	7.0	30.0	28.1	28.7	116.3	153.0
	(31.8)	(20.4)	(26.1)			(238.8)	(14)	(7.6)	(29.4)	(28.0)	(27.9)		
May	30.7	22.4	26.6	34.9	19.6	648.6	20	5.4	29.8	27.8	28.8	121.9	153.0
	(31.9)	(22.8)	(27.4)			(372.2)	(19)	(6.6)	(30.6)	(29.4)	(29.8)		
June	30.6	24.6	27.6	35.8	21.6	634.5	28	2.4	30.0	28.3	29.6	65.4	119.8
	(31.6)	(24.4)	(28.0)			(594.6)	(24)	(4.1)	(30.6)	(29.7)	(28.6)		
July	33.3	25.3	29.3	37.0	23.7	342.2	23	5.6	32.4	30.5	31.5	136.7	174.3
	(32.1)	(25.0)	(28.6)			(530.7)	(27)	(4.4)	(31.4)	(30.5)	(30.4)		
August	32.5	25.1	28.8	35.5	23.8	520.9	23	5.9	31.8	29.3	31.2	137.7	167.0
	(32.1)	(24.8)	(28.4)			(439.0)	(25)	(4.8)	(31.4)	(30.6)	(30.6)		
September	32.7	24.3	28.5	35.2	22.9	361.9	21	5.2	31.2	?	31.0	105.0	141.0
	(32.4)	(24.5)	(28.4)			(337.5)	(18)	(5.7)	(31.9)	(30.5)	(30.6)		
October	32.4	23.0	27.7	35.6	20.0	138.5	9	7.3	30.8	?	30.2	81.6	140.2
	(31.2)	(22.4)	(26.8)			(220.7)	(11)	(6.5)	(29.4)	(28.9)	(29.6)		
November	28.3	18.3	23.3	32.1	13.8	151.6	8	6.2	25.7	?	26.1	77.2	92.9
	(29.2)	(17.0)	(23.1)			(21.5)	(2)	(8.0)	(25.9)	(25.5)	(26.1)		
December	25.7	12.7	19.2	27.6	10.3	82.9	4	8.0	21.4	?	22.2	70.4	76.8
	(27.0)	(12.5)	(19.8)			(6.8)	(1)	(8.1)	(22.8)	(22.4)	(23.2)		

Per cent relative humidity

Table 2(a). Silcoorie (Cachar)

Hours of Observation IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0619	99	96	97	90	93	97	94	95	95	96	96	99
	(98)	(97)	(93)	(91)	(91)	(95)	(96)	(96)	(95)	(96)	(97)	(98)
1319	46	43	40	64	77	82	71	72	69	68	66	59
	(46)	(43)	(43)	(56)	(67)	(76)	(75)	(74)	(71)	(67)	(56)	(48)

Note : (i) Data in brackets shows previous datas of averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon reading.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1973

Table 3. Nagrakata (Dooars)

Latitude : 26°54′ N Longitude : 88°55′ E Altitude : 228.6 meters a.m.s.l.

Month 1973	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (Under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	23.2	11.4	17.3	26.7	9.0	4.3	2	5.7	19.2	19.6	20.3	65.0	59.2
	(23.7)	(10.4)	(17.1)			(11.8)	(2)	(7.9)	(18.1)	(18.3)	(19.5)		
February	26.9	14.2	20.6	29.0	10.0	29.7	3	7.1	22.3	21.9	21.4	98.6	91.5
	(25.4)	(12.8)	(19.1)			(20.5)	(3)	(7.5)	(20.1)	(19.8)	(20.6)		
March	30.8	16.8	28.8	36.1	12.5	11.9	5	7.6	24.8	24.6	24.2	157.5	140.4
	(29.3)	(16.4)	(27.8)			(43.8)	(5)	(7.7)	(24.0)	(23.4)	(28.6)		
April	33.0	21.6	27.3	36.1	18.5	120.7	7	7.2	29.4	28.6	28.6	193.8	171.9
	(30.0)	(19.9)	(24.8)			(144.4)	(11)	(7.2)	(26.8)	(24.2)	(26.4)		
May	30.7	21.9	26.3	33.4	19.5	517.5	23	6.4	28.4	28.6	28.4	158.2	165.5
	(30.8)	(21.7)	(26.2)			(329.9)	(20)	(6.6)	(28.4)	(27.6)	(27.9)		
June	29.7	23.6	26.6	35.0	21.7	1086.6	27	3.3	27.1	28.1	28.1	91.2	125.6
	(30.3)	(23.3)	(26.8)			(889.3)	(26)	(3.8)	(28.6)	(28.0)	(28.4)		
July	31.6	24.6	28.1	34.5	23.0	701.7	24	4.3	29.3	29.2	29.3	136.4	146.2
	(30.3)	(23.8)	(27.1)			(1081.1)	(27)	(3.4)	(29.0)	(28.3)	(28.7)		
August	31.6	24.1	27.8	35.0	22.4	751.1	21	4.9	28.6	28.6	28.5	118.5	150.8
	(30.6)	(23.7)	(27.2)			(775.4)	(28)	(4.0)	(29.2)	(28.8)	(29.0)		
September	30.6	23.4	27.0	34.5	21.5	449.8	23	4.3	28.4	28.4	28.7	99.0	119·9
	(30.6)	(22.9)	(26.8)			(555.3)	(21)	(5.2)	(28.8)	(28.8)	(28.8)		
October	29.7	20.3	25.0	33.1	16.9	349.5	9	7.0	26.8	26.9	27.3	108.2	132.5
	(29.8)	(19.4)	(29.6)			(200.8)	(10)	(7.8)	(26.8)	(27.2)	(27.2)		
November	28.2	15.1	21.6	30.8	12.8	1.3	1	9.4	22.8	23.2	24.2	89.3	101.8
	(27.2)	(14.6)	(20.9)			(14.0)	(3)	(8.6)	(22.6)	(23.0)	(24.1)		
December	24.7	11.6	18.2	27.0	9.3	3.1	1	8.1	19.4	20.1	21.2	66.0	71·0
	(24.9)	(11.5)	(18.2)			(4.0)	(1)	(8.5)	(19.5)	(19.8)	(21.1)		

Per cent relative humidity

Table 3(a). Nagrakata (Dooars)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0634	88	80	71	74	89	96	94	94	96	93	84	90
	(85)	(81)	(74)	(76)	(87)	(95)	(96)	(95)	(95)	(88)	(85)	(85)
1334	52	43	38	47	67	85	80	79	80	73	53	54
	(52)	(49)	(46)	(53)	(69)	(82)	(83)	(82)	(78)	(66)	(57)	(53)

Note : (i) Data in brackets show previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon reading.
(iii) Penman in mm means Penman estimate of evaporation from an open water surface.

Summary of meteorological observations during 1973

Table 4. Nagri Farm (Darjeeling)

Latitude : 26°55′ N Longitude : 88°12′ E Altitude : 1,15[illegible],24 Meters a.m.s.l.

Month 1973	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (Under grass)			Monthly Evaporation	
									Depth				
	Mean Max.	Mean Min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January	14.2	7.5	10.8	17.1	5.0	13.8	8	4.5	13.6	11.7	14.0	27.3	49.9
	(15.2)	(7.8)	(11.5)			(19.4)	(3)	(6.3)	(13.2)	(12.5)	(14.1)		
February	18.2	10.5	14.4	21.3	8.0	20.8	4	5.5	16.1	14.2	15.1	50.8	76.4
	(16.6)	(9.4)	(13.0)			(18.1)	(4)	(5.9)	(14.6)	(13.5)	(14.5)		
March	22.8	13.7	18.8	29.3	8.2	51.5	4	7.7	19.0	16.6	17.8	105.4	132.6
	(21.0)	(13.0)	(17.0)			(54.4)	(5)	(6.7)	(18.9)	(17.2)	(17.6)		
April	25.6	17.7	21.6	29.1	14.0	82.8	9	6.5	23.6	21.3	22.2	127.1	148.0
	(23.5)	(15.7)	(19.6)			(97.8)	(10)	(5.6)	(21.6)	(20.0)	(20.2)		
May	24.1	17.0	20.6	26.9	15.2	167.7	19	4.8	23.7	21.6	22.4	80.0	133.9
	(23.8)	(17.2)	(20.5)			(200.3)	(19)	(5.3)	(23.6)	(21.8)	(22.0)		
June	24.3	19.1	22.7	27.6	17.9	627.6	26	2.6	24.1	23.0	23.3	59.5	111.2
	(24.1)	(18.8)	(21.4)			(420.5)	(25)	(3.0)	(24.5)	(23.2)	(23.2)		
July	26.7	19.8	23.2	30.0	19.0	409.5	24	4.1	24.9	23.8	24.6	78.4	134.9
	(24.2)	(19.4)	(21.8)			(668.3)	(27)	(2.4)	(24.8)	(23.6)	(23.8)		
August	26.1	19.3	22.7	29.9	17.1	549.4	20	4.5	26.0	23.8	24.7	81.6	130.7
	(24.7)	(19.1)	(21.9)			(465.7)	(26)	(3.2)	(25.2)	(23.8)	(24.2)		
September	25.3	18.3	21.8	28.3	17.0	198.8	17	4.0	25.8	22.5	24.4	68.0	108.4
	(24.4)	(18.2)	(21.3)			(325.3)	(20)	(4.0)	(24.2)	(23.2)	(23.7)		
October	23.8	16.2	20.0	26.9	13.0	410.0	7	6.1	22.4	19.8	22.1	60.7	104.2
	(23.2)	(15.6)	(19.4)			(128.4)	(8)	(6.8)	(22.1)	(21.0)	(21.8)		
November	22.4	12.3	17.4	23.9	8.0	34.0	1	8.5	18.8	16.4	19.0	64.7	88.1
	(20.1)	(11.8)	(16.0)			(11.4)	(3)	(7.2)	(18.1)	(17.2)	(18.7)		
December	17.8	9.4	13.6	21.2	7.2	0	0	6.8	15.2	12.9	16.2	44.1	60.1
	(17.7)	(9.3)	(13.5)			(2.4)	(1)	(7.0)	(14.8)	(14.0)	(15.7)		

Per cent relative humidity

Table 4(a). Nagri Farm (Darjeeling)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637	79	68	55	58	83	93	89	86	88	81	64	67
	(71)	(70)	(64)	(69)	(80)	(92)	(94)	(93)	(89)	(76)	(68)	(69)
1337	76	61	48	55	81	90	82	81	80	80	62	69
	(72)	(65)	(60)	(67)	(82)	(89)	(90)	(87)	(86)	(79)	(72)	(70)

Note : (i) Data in brackets shows previous averages.
(ii) Soil temperature at different depths are the mean of morning and afternoon reading.
(iii) Penman's in mm means Penman estimation of evaporation from an open water surface.

Summary of meteorological observations during 1973

Table 5. North Bank (Assam)

Latitude : 26°48′35″ N Longitude : 92°42′35″ E Altitude : 92.45 meters a.m.s.l.

Month 1973	Daily temperature °C					Rainfall		Daily sunshine in hours	Daily soil temperature °C (Under grass)			Monthly Evaporation	
	Mean Max.	Mean Min.	Mean	Highest	Lowest	monthly in mm	Day with 0.03 mm and above		Depth 5 cm	15 cm	30 cm	Open pan in mm	Penman in mm
January													
February													
March													
April	31.7	20.9	26.3	36.6	19.0	201.6	14	7.2				138.2	163.6
May	31.5	22.3	26.9	38.3	20.4	266.0	18	6.3				109.4	166.0
June	31.0	24.7	27.8	36.6	22.6	508.1	23	3.5				94.6	134.8
July	33.6	25.6	29.6	37.0	23.5	362.6	13	6.0				125.5	176.4
August	32.4	25.2	28.8	36.8	23.6	236.5	15	5.5				92.8	160.3
September	31.8	23.7	27.8	35.5	16.8	227.9	19	5.4				83.3	136.1
October	30.9	21.2	26.1	34.1	16.7	132.6	10	7.0				75.6	128.7
November	28.0	14.8	21.4	30.1	10.0	30.6	3	7.4				56.4	86.5
December	24.8	9.6	17.2	27.4	9.6	25.3	3	7.7				47.3	63.5

Per cent relative humidity

Table 5 (a). North Bank (Assam)

Hours of Observations IST	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0637				84	90	95	93	95	93	92	94	96
1337				60	70	79	71	75	76	70	62	63

Note : (i) Penman's in mm means Penman estimation of evaporation from an open water surface.
(ii) North Bank station newly opened on 1973 April and hence no previous records.